POTENTIALS OF FOREST ECOSYSTEM SERVICES FOR PRIMATE CONSERVATION AND HUMAN WELLBEING

Abu Saleh Md. Golam Kibria

Candidate ID: u5429511

Dissertation has been submitted for the fulfilment of the requirements for the degree of Doctor of Philosophy

Department of Biological Anthropology

School of Archaeology and Anthropology

College of Arts and Social Sciences

Australian National University

May 2018

STATEMENT OF ORIGINALITY

The work presented in this thesis is, to the best of my knowledge and belief, original and my own work except where otherwise acknowledged. This material has not been submitted either in whole or in part, for a degree at this or any other university.

The chapter-3 has been published and Chapter-5 is in press for publication in the journal *Ecosystem Services*. The details are as follows:

Chapter 3:

Kibria, A.S.M.G., Behie, A., Costanza, R., Groves, C., Farrell, T., 2017. The value of ecosystem services obtained from the protected forest of Cambodia: The case of Veun Sai-Siem Pang National Park. Ecosystem Services 26, Part A, 27-36.

Chapter 5:

Kibria, A.S.M.G., Costanza, R., Groves, C., Behie A., (in press). The interactions between livelihood capitals and access of local communities to the forest provisioning services of Sundarbans mangrove forest, Bangladesh. Ecosystem Services.

I hereby certify that the above information are true and correct as to the best of my knowledge.

……..

Abu Saleh Md. Golam Kibria

Word count: 70,553 (all inclusive)

Acknowledgements

All praise to Allah SWT, for cherishing my life with this wonderful achievement by enabling me to complete the dissertation with great patience and perseverance. I am immensely grateful to Dr. Alison Behie (Chair) and other supervisors Prof. Robert Costanza, Prof. Colin Groves from The Australian National University and Dr. Tracy Farrell (Vice President, Strategy and Fundraising, Asia Pacific Division, Conservation International (CI)) for their incredible support at every stage of the research.

This research is supported by an Australian Government Research Training Program (RTP) Scholarship. I am also very grateful to the Rufford Foundation, UK and The Australian National University (ANU), Australia for funding the research. I acknowledge the support from the Statistical Consultation Unit of ANU for providing valuable advice during data analysis. I also thank two anonymous examiners for helpful comments on this thesis.

I would like to thank CI for providing support on the field during data collection. In particular, Bunra Seng (Country Director, CI Cambodia), Andrew Billingsley (Landscape Manager, CI Cambodia), Chenton Cheb (CBET site officer, CI Cambodia) and other anonymous indigenous people without who I would be able to gather data in the remote area of Veun Sai- Siem Pang National Park (VSSPNP).

I am very grateful to Mr. Hashem Miah, Mr. Shariful Islam and Mr. Md Atiar Rahman from the Centre for Natural Resource Studies (CNRS), Dhaka, for their cordial support during the field work. I also acknowledge the support of Mr. Mohtasem Billah (Program Co-ordinator, Winrock International) and Mr. Abdullah Al-Mamun (Assistant Professor, University of Chittagong) for their valuable support in making the data collection a great success. My thanks go to all the village-headman and villagers for offering their best

support for data collection as well as their concern in maintaining safety and welfare in the field.

My utmost gratitude go also to my beloved parents who made an incredible amount of sacrifice for this accomplishment. It has been a long battle to reach up to the point and I could not find better persons by my side during the hard days. I also thank all other family members including my wife, sisters and parents-in-law for their inspirations and endless support that encouraged me for this accomplishment.

Table of Contents

List of Tables

Table **Page**

List of Figures

Figure **Page**

List of Appendices

Appendix **Page**

Abstract

Ecosystems supply numerous valuable services which are crucial for maintaining human wellbeing. However, the value of these Ecosystem Services (ESS) are yet to be fully captured or quantified and how they contribute to ecosystem conservation and the wellbeing of people are not properly understood. This thesis aims to add to this knowledge through the use of four case studies from two forests in Asia. Using these two important forests, this research project aimed to answer four key research questions: 1. What is the estimated value of the ESS obtained from the forest ecosystem? 2. What are the potentials of recreational service based management in sustainable conservation? 3. What are the interactions between livelihood capitals and access of local communities to the forest ecosystem services and how does this impact their daily lives and wellbeing? 4. What are the potentials of ecosystem services for improving human wellbeing of directly dependent communities? The case studies were conducted at the Veun Sai-Siem Pang National Park (VSSPNP) in Cambodia, and the Sundarbans Mangrove Forest (SMF) in Bangladesh. In order to estimate the value of VSSPNP, I used academically well-established formulas and methods for each service. Primary data were collected by conducting interview and secondary data were obtained from published literature and official records of the respective authorities. I estimated the total annual contribution of VSSPNP to be US$129.84million contributed by air purification, water storage, soil-erosion reduction, soil-fertility improvement, carbon sequestration, provisioning services and recreation. The area also generated valuable non-monetary values including academic and non-academic knowledge, created a diverse network worldwide, and shaped the culture of local indigenous people. Given the high value of the area, a properly designed ecosystem-based ecotourism program (CBET) was developed. This program was assessed in terms of its impact on human wellbeing by surveying the demography of

tourists and their conservation attitudes towards the CBET program. In total 36 tourists were interviewed twice (before and after visiting the site). In addition, data were collected from the official records of the management authority (Conservation International or CI), face to face interviews with 35 indigenous families and focus group discussions with local people including both CBET members and non-members. I found that the CBET program increased the recreational value of VSSPNP and there was a significant improvement in the level of satisfaction of the tourists after visiting the site. CBET also significantly increased the intention for collective action and cooperation for conservation of the forest amongst people. Similarly, in the Shyamnagar upazila vicinity of the Sundarbans Mangrove Forest (SMF), I conducted interviews with the heads of 104 households to determine the level of access to provisioning services (a type of ESS) to better understand the trade-offs made by the households when selecting which services to use. I found that the interactions between livelihood capitals (human, physical, financial, natural and social) are key contributors to the level of access a person has to a given service and that PS contributed significantly in availability and cleanliness of non-drinking water as well as significantly improving the capacity of people to maintain social freedom. I then divided these 104 households into high access (income≥ US$893/yr) and lower access (<US$893/yr) families based on the income they received from provisioning service collection and collected data on four general wellbeing criteria. The effect of each criterion on wellbeing was measured and showed that only physical health and economic security significantly improved with the increase in PS collection as food sufficiency was significantly decreased with the increase in the amount of PS collection. A higher amount of PS extraction also tends to significantly weaken the collectors physically while mental health decreased. These case studies suggest a participatory approach of forest conservation has the potentials to make a difference for wildlife and human populations and these relationships need to be better understood to

fully understand how important forests are for local people. This will help make better conservation action plans that ensure forests are maintained and that people's expectations of how they can use the forest are secured.

Chapter 1

General introduction and thesis overview

Forest ecosystems include the land areas with vegetation, fauna, and micro-organisms which are the sources of diverse goods and services which are collectively referred to as Ecosystem Services (ESS). According to the common definition of ESS, these include food, water, fuel, timber, fibre, climate regulation, flood regulation, disease regulation, water purification, spiritual and recreational services, just to name a few (MEA, 2003, Fisher *et al.*, 2014). These services have been the part and parcel to maintain and flourish human existence on earth (Daily, 1997, Daw *et al.*, 2011). Despite their recognised importance, ESS have been largely ignored in the development of forest and environmental policies. Although some contributions of forests (e.g. timber, bush-meat, honey, fuelwood, medicines etc.) are considered in the conventional economic contributions, the true values of forests are grossly underestimated in conservation plans. This simplified view of forest value often led to the conversion of forests to agricultural land and a lower investment in forest conservation (Daily *et al.*, 2009, Costanza *et al.*, 1997). Given this, it is necessary to scale up efforts to quantify as well as explicitly integrate the entire and complex picture of ESS in policy decisions and management plans in order to ensure sustainable conservation of forest ecosystems and human wellbeing.

There is a general concern showed by some researchers and activists that valuation of ESS would eventually privatize our nature and put them in the market for trading (Monbiot, 2012, Costanza, 2006). This argument has failed to differentiate between 'price' and 'value' (Dodds, 1991). Knowing the value of ecosystem services is crucial for recognizing the number of contributions the ecosystems make, which do not necessarily

include financial incentives. The values of ecosystems are considered sub-consciously or unconsciously in deciding trade-offs between nature conservation and development; hence, the values remain hidden in actual policy decisions. Hence, precise valuation of ESS would assist us to formulate better policy for sustainable development of the humanity (Costanza *et al.*, 2014). Monetary and non-monetary values can complement each other and assist in generating greater ESS by facilitating communications between stakeholders and enabling comprehensive evaluation that frames all the aspects of an ecosystem's contribution within the broader ESS framework (Daniel *et al.*, 2012, deGroot *et al.*, 2010). Hence, an attempt has been taken to measure the contributions of the ecosystem by considering the services it has been generating. These values would make the ecosystem more important and thereby, would assist in convincing policy makers for more proactive actions to conserve the forest.

Communities living around forests are largely dependent on them for their subsistence as they utilise many forest products in daily life. For example, many local communities rely heavily on the collection of different provisioning services including timber, bamboo, honey, resin, rattan, bush-meat, medicinal plants etc. from the forests for income, household consumption, and coping with stresses and shocks (Babulo *et al.*, 2008, Kalaba *et al.*, 2013). Increasing population size and decreasing fertility of cleared lands are likely to threaten the forest area through human encroachment and over-exploitation of resources. Therefore, gaining access to the goods and services provided by forests is more important than the availability of ESS especially from the perspective of the poorest individuals (Leach *et al.*, 1999, Sen, 1983). While some research has examined the factors which dictate livelihood decisions of ecosystem dependent people, there has been no study that has explained the composite effect of livelihood capitals in deciding various ESS extraction (Cinner et al., 2009; Bhandari, 2013; Liu and Liu, 2016; Hua et al., 2017). This leaves a considerable knowledge gap in our understanding of the complex

interactions of livelihood capitals. Access to the resources ensures essential benefits to local communities. One way to assess the level of access (or ability to benefit) is by the income generated from a resource (Ribot and Peluso, 2003, Ribot, 1998). Considering the natural resources as the 'things' the ability of people to benefit from 'things' depends on the range of powers exercised through various mechanisms (Ribot and Peluso, 2003). Thus, a given type of benefits and beneficiaries embody various sets of power relations around them (Ribot and Peluso, 2003, Brosius and Russell, 2003). Equitable and sustainable wellbeing depend heavily on the links with ecosystem services, and who gains and who loses from their use. Thus, wellbeing is largely reliant on the ability of the people to use the resources. Therefore, the access analysis involves identifying and mapping the flow of the benefit, mechanisms by which different actors gain access (Ribot and Peluso, 2003). The ability to benefit can be presented as the interactions among the five types of livelihood capitals- natural, human, financial, physical and social capital (Fisher *et al.*, 2014, Costanza *et al.*, 2014). Livelihood capitals are undoubtedly interrelated with each other and thereby, make the human-nature relation so dynamic. Wider understanding the livelihood capital-access nexus is crucial to protect any ecosystem from over-exploitation as well as improve human wellbeing.

Venu Sai Siem Pang National Park (VSSPNP) and the Sundarbans Mangrove Forest (SMF) are the two of the most important forests in South and South-east Asia because of the richness in biodiversity. These two forests are large and have had relatively little disturbance compared to the other sites surrounding them, making them important sources of ESS (Iftekhar and Islam, 2004a, Ramachandra *et al.*, 2012). The threats faced by these ecosystems largely represent the challenges of the forest ecosystem management in the developing countries of the Asian region. VSSPNP contains primate species of great conservation interests in including the gibbons as it is believed to be the biggest population of the species *Nomascus annamensis* in existence globally (Rawson and Bach,

2011). The SMF is also home of many magnificent animals notably Royal Bengal Tiger (*Panthera tigris*). Both ecosystems offer myriad ESS which are crucial to the local people to survive. However, increased demand from the growing population around the forests forced many species to be endangered leading to the unsustainable management of the ecosystems.

Conservation initiatives such as Community Based Ecotourism (CBET) potentially are complementary to the value of ecosystem and local wellbeing. Most of the studies which are performed to analyse the effects of CBET on the local people are lack of robustness in defining human wellbeing. As local villagers rely on the forest for PS to maintain their wellbeing, any reduction in access to these resources and services also put people under threat. Lack of control on the access to certain PS leads to unsustainable harvesting and may cause large-scale biodiversity loss. Hence, controlling of access to a certain resource can largely be achieved by manipulating the outcomes of the livelihood capitals of the households (Bebbington, 1999). As the status of livelihood capitals of people determines their ability to consume any PS, understanding the interactions between the livelihood capitals and access to PS of these ecosystem dependent societies is essential to achieving sustainability in natural resource management. Despite the widespread research initiatives to understand the contributions of an ecosystem on local wellbeing, the mainstream view of wellbeing is still being heavily focused on economic growth (Blanchflower and Oswald, 2004, Stewart, 2005). This research is designed also to fill in the gap by exploring the relationship between access to ESS and human wellbeing. Results of this study can be used for wider understanding of the complex relationship between ESS and human wellbeing and assist new research initiatives devoted to attain sustainable development.

1.1 Research objectives

The notion of ESS has been largely ignored in forest and environmental policies. Thus, forests have been undervalued in terms of their financial benefits and how they impact the livelihoods of millions of people. Ecosystem services cannot be fully captured or quantified simply by comparing them to commercial market products. Rather, more nuanced and complete case studies are needed that fully quantify and qualify the ESS value of forests throughout the world and how they contribute to the livelihood of people. This thesis aims to do just that through the use of four case studies from two forests in Asia.

The first two case studies were done at VSSPNP. This forest contains significant populations of rare and endangered species including Northern buff-cheeked gibbons (*Nomascus annamnesis*), red-shanked douc langur (*Pygathrix nemaeus*), the giant ibis (*Thaumatibis gigantean*) and is home to several indigenous hill tribes and other people including Brao, Lao, Kavet, and Kinh. Due to chronic poverty, illegal logging and poaching activities are threatening the site's ecological integrity. On May 09, 2016, VSSPNP is declared as a protected area to provide better means to conserve the richness of the forest. Conservation International has been running a community based ecotourism (CBET) program in the forest, but in the absence of an estimation of ESS provided by the area attracting greater investment and attention towards its protection has been very challenging. Moreover, understanding the effects of the CBET on the wellbeing of the local people is crucial to successful implementation of CBET which has never been studied before. To address this research gap and examine whether the ESS based conservation project will improve the indigenous people's wellbeing. By these case studies, I addressed two hypotheses: 1) the value of the Ecosystem Services obtained

from the forest ecosystem is undervalued; 2) recreational service based management in sustainable conservation has the potentials in achieving sustainable conservation goals.

The next two case studies were done at Sundarbans Mangrove Forest (SMF) which is a world heritage site declared by the UNESCO. This forest is the single large mangrove forest in the world and home to many endangered wildlife species. With over 3.5 million people from the surrounding areas depending on the (SMF) for their livelihoods, the reduction of forest coverage (0.04% per year) is alarming (Iftekhar and Islam, 2004a; Abdullah et al., 2016). As local villagers rely on the forest for PS to maintain their wellbeing, understanding the access to the ESS obtained from Sundarbans and their effect on the wellbeing of dependent communities are the central issues of sustainable management of SMF. By these two case studies I addressed two hypotheses: 1) there are interactions between livelihood capitals and access of local communities to the forest ecosystem services; 2) ecosystem services are potentials in improving the human wellbeing of directly dependent communities.

Using these two important forests, this research project aimed to answer four key research questions:

1. What is the estimated value of the Ecosystem Services obtained from the forest ecosystem (at VSSPNP)?
2. What are the potentials of recreational service based management in sustainable conservation (at VSSPNP)?
3. What are the interactions between livelihood capitals and access of local communities to the forest ecosystem services and how does this impact their daily lives and wellbeing (at SMF)?
4. What are the potentials of ecosystem services for improving human wellbeing of directly dependent communities (at SMF)?

1.2 Thesis Overview

Chapter 1 briefly introduces the research problem and case studies being used to answer the questions of interest. It also addresses the significance of the research and how outcomes may be able to address concerns about the way we currently undervalue forests as well as the complexities of the relations between the forests and the dependent communities.

Chapter 2 describes the extensive literature for portraying the context and creating a greater understating of all the relevant issues and terminologies of the study.

Chapter 3 provides for the first time a valuation of Veun Sai-Siem Pang National Park (VSSPNP) in Cambodia, which is a forest largely unfamiliar to the international community yet extremely significant in terms of biodiversity value. I estimated the total annual contribution of VSSPNP by measuring the values of air purification, water storage, soil-erosion reduction, soil-fertility improvement, carbon sequestration, provisioning services and recreation. By analysing the published articles and reports on VSSPNP I determined the area had generated valuable academic and non-academic knowledge on natural resources. This forest had also created a diverse network among scientists and different organizations worldwide. I also identified the forest to be of cultural importance for indigenous people.

Chapter 4 explores the potentials of a community based ecotourism program (CBET) based on viewing gibbons in VSSPNP of Cambodia. The study is based on data collected by interviewing tourists who were interviewed twice (before and after the visit), and households interview conducted with local villagers. I explored the change in the recreational value of the forest and the level of satisfaction of the tourists after visiting the site. I also compared the before and after scenarios of the wellbeing of the local people as the community based ecotourism projects are designed to improve local people's welfare

by creating alternative income generation and thereby reduce dependency to the ecosystem.

Chapter 5 aims to understand the level of access of the villagers and the influence of livelihood capitals on the access to Provisioning Services (PS) of the Sundarbans Mangrove Forest (SMF) in Bangladesh. Data were collected by interviewing households randomly selected from nine different villages. I described the level of access to honey, mixed fish, shrimp fry, shrimp, and fuelwood. This chapter also examined the complex indications of livelihood capitals and access to the PS obtained from SMF.

Chapter 6 presents the influence of Ecosystem Services (ESS) on human wellbeing by comparing higher and lower access groups. The data were collected by interviewing randomly selected households as well as key informants of the villages around SMF of Bangladesh. The wellbeing in this study consists basic materials of life, health and sanitation, security, freedom of choice, and social relation.

Chapters 7 and 8 put the case studies into a bigger context of ESS value in South and Southeast Asia by comparing results to identify common themes and factors which are essential for sustainable conservation as well as improving human wellbeing.

1.3 Ethics and permissions

The research was conducted with the approval of The Australian National University Human Research Ethics Committee (HREC). The details of the protocol are: Record number: 6780; Protocol type: Expedited Ethical Review (E2); Ethics program type: Postgraduate. End date: 25/12/2015. Conducting the field work for the also had permission from the School of Archaeology and Anthropology, College of Arts and Social Science (CASS).

Chapter 2

Background literature

2.1 Ecosystem services (ESS)

Humans rely on natural systems for both survival as well as improving their levels of wellbeing. These benefits are broadly conceptualized as ESS. Thus, ESS, which include the components of natural ecosystems (e.g. water, air, food, scenic beauty etc.) that humans directly enjoy or use to maintain the human-wellbeing (Boyd and Banzhaf, 2007, Costanza *et al.*, 1997). The services delivered by ecosystems have been crucial to the functioning and growth of humanity as millions of rural people in developing nations rely on them every day. Interest in the concept of ESS has grown sharply since the 1980s when ecosystem services first entered into the academic lexicon and has since gradually been becoming an organizing principle in the international natural resource conservation policy arena (Ferraro *et al.*, 2011). In 2001, Millennium Ecosystem Assessment (MEA) pooled more than 1300 leading experts to assess the effects of ecosystem change on human wellbeing, which serves as the scientific basis for increasing efforts in ecosystem conservation to enhance their contributions to human wellbeing (MEA, 2005, Ferraro *et al.*, 2011). This approach promoted by MEA as a framework has become a pioneering tool for actions under the international Convention on Biological Diversity. In the last decade, most international conservation organizations have engaged themselves in this ecosystem approach (Ferraro *et al.*, 2011).

MEA has successfully created a wider understanding and offered a general classification for ESS. While this classification does not fit all purposes and contexts of environmental accounting and management for which alternative classifications have been proposed (Boyd and Banzhaf, 2007), the MEA classification is still the most widely used in the

relevant literature (Carreño *et al.*, 2012, Daw *et al.*, 2011). Following MEA classification, the TEEB (The economics of ecosystems and biodiversity) classification was also largely accepted in the academic community (La Notte *et al.*, 2017, Kalaba *et al.*, 2013) (Table 2.1).

Table 2.1: Different types of ecosystem services.

MEA classification	**TEEB classification**
Provisioning	***Provisioning***
Food	Food
Fresh water	Water
Genetic resources	Raw materials
Fibre	Medicinal resources
Biochemical	Genetic resources
Ornamental resources	Ornamental resources
Regulating	***Regulating***
Air quality regulation	Air purification
Water regulation	Climate regulation
Climate regulation	Disturbance prevention or moderation
Soil formation	Erosion prevention
Erosion control	Maintaining soil fertility
Pollination	Regulation of water flows
Pest regulation	Waste treatment
Human disease regulate	Pollination
	Biological control
Supporting	***Habitat***
Photosynthesis	Lifecycle maintenance
Nutrient cycling	Gene pool protection
Primary production	
Cultural	***Cultural***
Aesthetic values	Aesthetic information
Recreation and ecotourism	Recreation and tourism
Cultural diversity	Inspiration for culture, art and design
Spirit and religious values	Spiritual experience
Knowledge system	Information for cognitive development
Education values	

Source: (Kumar, 2010, Fisher *et al.*, 2009, Ninan and Inoue, 2013, Smith *et al.*, 2013).

2.1.1 Provisioning services

Provisioning ecosystem services are those products that can be harvested including timber, food, water and many other goods are consumed by the people for their material benefits. Many of these provisioning services are profitable commercial products and traded in markets. In many parts of the world, rural households are also directly dependent on the services for their subsistence (MEA, 2005, Fisher *et al.*, 2009).

2.1.1.1 Food

Despite massive commercial food production, a large portion of human diet is still obtained from wild sources. Natural ecosystems are great sources for edible plants and animals including bush meat, fish, vegetables, fungi, and fruits. However, natural forest, grassland, and aquatic systems are often temporarily or partly used or converted to produce commercial foods, making such naturals systems even more valuable (de Groot *et al.*, 2002). One example where this becomes apparent is the use of wild mushrooms in Asian communities. Mushrooms are traditionally used as a food item by many Asian communities. Wild mushrooms are higher in protein than many vegetables, rich in minerals and vitamins (Mattila *et al.*, 2001). Arhorchin Mongol herdsmen have been using wild plants in their diets for generations. Historically, wild plants were the major source of the traditional diet composition of the indigenous Mongolian community. But with the advancement of technology and the mass production of commercial foods, the importance of wild food has been reduced, although some of these items still remain as a supplement to the dependent families (Huai and Pei, 2000).

Another great example is bush-meat which is an important source of protein in many urban and rural areas of Africa where domestic meats are not available (Wilkie and Carpenter, 1999). It is also a source of income for many people as hunters can sell this

meat. Noss (2002) reported that snare hunters in Dzanga-Sangha special forest reserve in South-western CAR can make more money (US$40-58 per month) than the CAR official minimum wage (US$38 per month) highlighting the importance of this ESS for the survival and wellbeing of some communities.

From a health standpoint, wild plants are known to have higher mineral contents than commercially produced plant items. Moreover, unlike farmed foods, wild foods are devoid of harmful chemical compounds. The decline of wild items in the diet due to land conversion and reduced availability may help to explain why over two billion people worldwide suffer from micronutrient malnutrition and general poor health (Flyman and Afolayan, 2006, Thompson and Amoroso, 2010).

2.1.1.2 Raw materials

Raw materials are the renewable biotic components of the ecosystems such as timber, fibres, latex, gums, oils, wax, tannins, hormones etc. that are used for industrial purposes or as energy resources (de Groot *et al.*, 2002). Within this category comes the world timber trade, which is already regarded as a vital part of the international trade (Hillring, 2006). International timber trade is also one of the most important causes of tropical deforestation (Burgess, 1993).

Other than timber, two of the most important raw materials are medicinal resources and fuel-wood. Nature contributes to human health by supplying chemicals that can be directly used as medicine or used to synthesize the medicines. Until the mid-nineteenth century wood was a principal source of energy worldwide. But it has since been rapidly replaced by more convenient sources of fuels including coal, oil gas and electricity. Yet, across the developing regions wood-based fuel has remained a dominant fuel. Traditional

use of biomass fuel is still relevant in the world, as it contributes 10–15% of the global energy consumption (Arnold *et al.*, 2003).

Historically, non-timber forest products (NTFPs), wild foods (i.e. mushroom, bamboo shoot, honey, fish, bush-meat etc.), cane, bamboo, medicinal plants, aromatic plants, gums and resins, fibre and floss, fodder and forage species and many more were primarily used for local consumption, and large-scale commercial extraction was characterised as unprofitable (Schwartzman and AKO Nepstad, 1992). However, in the last two decades, there has been a growing interest in understanding the contributions of NTFPs to rural communities and the sustainable conservation of natural resources. Ecologically, extraction of NTFPs is less destructive than harvesting timber and conversion of forest land for another purpose, and thereby can promote sustainable forest management. Moreover, increased commercial demands for NTFPs can add to the perceived value of the forest ecosystem that would lead to increase the incentives to conserve the forest resource (Arnold and Pérez, 2001). Balick and Mendelsohn (1992) argued that income from sustainable harvesting of NTFPs potentially can be higher than timber harvesting, or income from the converted forest lands for agricultural productions.

2.1.1.3 Genetic resources

Many biotic resources, that were once wild, are now available from commercial cultivation and domestication. In order to increase the productivity of existing crops or to invent high yield varieties (HYVs), regular support from the genetic material of wild species remains essential (de Groot *et al.*, 2002). The use of wild crop genes to improve the performance of related commercial crops has been exercised for more than 60 years. There has been a sharp increase in inventing high yield cultivars by reconstituting genetic structure with the genes taken from wild varieties. Although the primary interest in using

this technology is increasing disease and pest resistance, a wide range of uses have emerged in recent years. For example, crops whose wild relatives (e.g. wheat, tomato) have traditionally been a source of useful crop varieties are under continuous genetic improvement (e.g. taste, colour, flavour) by introducing new genes from wild crops. Wild crops are increasingly gaining importance worldwide; however, their potentials in developing new varieties are yet to be properly utilized (Hajjar and Hodgkin, 2007).

2.1.2 Regulating services

Regulating services are referred to the benefits supplied by an ecosystem that act as a regulator, which may include natural hazard regulation, water purification, climate regulation, waste recycling, and pest control (Brander *et al.*, 2013). Natural ecosystems play a vital role in regulating and sustaining the earth's biosphere which depends on a very delicate balance between many ecological processes including biomass production, flow of minerals in food chains, bio-geochemical cycles and regulation of physical systems. All these processes are regulated by an interaction of different factors such as climatic conditions with living organisms (i.e. wildlife, microbes). Humans eventually benefit from these functions, but often they are not recognized (de Groot *et al.*, 2002).

2.1.2.1 Harmful gas regulation

Alterations of the balance in the chemical composition of our planet can have impacts on our natural as well as artificial systems. The chemical compositions of the earth's systems are directly linked to bio-geochemical processes, which are influenced by the myriad biotic and abiotic processes of the ecosystems. For instance, by regulating CO_2/O_2 balance forest ecosystems protect the ozone-layer as well as regulate SO_x gas levels. The main service of gas regulation provided by natural ecosystems is the maintenance of clean and breathable air (de Groot *et al.*, 2002). Urban forests can potentially remove a

large number of air pollutants that consequently reduce public health hazards. Nowak *et al.* (2006) reported that the removal of harmful gases (O_3, PM_{10}, NO_2, SO_2, CO) by urban plantation in the US is estimated at 711,000 metric tons ($3.8 billion value). Hence, establishing and managing urban forests could save huge national expenditure by assisting in meeting clean air standards (Freer-Smith *et al.*, 1997).

Terrestrial ecosystems also greatly influence the atmospheric composition by acting as a sink through the process of dry deposition of trace gas elements including sulphur dioxide (SO_2) and ozone (O_3). It is also an important source of VOCs (Volatile Organic Compounds) and some other important gases including nitrogen oxides (NO_x) (Ganzeveld *et al.*, 2002). Nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide are notable ambient air pollutants. Exposure to high-intensity NO_2 causes catastrophic injury including death and ambient NO_2 exposure may cause respiratory tract infections. Sulphur dioxide (SO_2) also causes damage to respiratory systems e.g. changes in airway physiology (Chen *et al.*, 2007).

Particulate pollution in the atmosphere is also recognised as a serious health concern globally (Beckett *et al.*, 1998). Koenig *et al.* (1993) reported that particulate air pollution hampers the pulmonary function of asthmatic children. Particle size in the atmosphere varies from sub-micron aerosols to barely visible grains of sand and dust. Vegetation of ecosystems can effectively trap and absorb many of these pollutant particles and thereby can act as a shield against many health issues (Beckett *et al.*, 1998).

Forest canopies can capture more particles than other vegetation because of their larger crown coverage. Crown surface of a forest can thus facilitate of the impact of such particles and accelerate turbulent deposition by increasing localized wind speed (Manning and Feder, 1980). It was found by Fritschen and Edmonds (1976) (cited in

Beckett *et al.* (1998)) that turbulence and wind speed significantly increase particle deposition in forest ecosystems. The features of surface structure also facilitates atmospheric particulate mixing, and reduce surface boundary layer resistance which leads to higher deposition of particulates (Croxford *et al.*, 1996).

2.1.2.2 Climate regulation

Through biogeochemical regulation, ecosystems reduce global concentrations of CO_2 and other greenhouse gases (GHGs) by storing those in soil and plant biomass (Chapin *et al.*, 2008). Ecosystems also influence the regional climates by maintaining the balance of water, energy, and other physical cycles in the lower atmosphere (Pielke *et al.*, 2002, Chapin *et al.*, 2008, West *et al.*, 2011). Tropical deforestation is thought to be responsible for approximately one-fourth of global carbon emissions, biodiversity loss, and diminishing ecosystem services. United Nations Framework Convention for Climate Change promotes the idea of avoiding deforestation, and minimizing the dangerous effects on earth (Kindermann *et al.*, 2008). Since 2007, efforts to minimize emissions due to the deforestation and forest degradation have widely accepted worldwide in order to ensure sustainable management, and increase forest carbon stocks through financial incentives which is known as REDD+ (Reducing greenhouse gas emissions from deforestation and forest degradation), dedicated to sustainable forest management (Clements, 2010). Kindermann *et al.* (2008) estimated that avoiding deforestation is a cheaper option in reducing GHGs from the atmosphere. Only 10% reduction in deforestation could save \$0.4 billion to \$1.7 billion yr^{-1} by reducing 0.3–0.6 Gt (1 Gt = 1 × 10^5 g) $CO_2 \cdot yr^{-1}$ emission from 2005 to 2030 which is worth \$0.4 billion to \$1.7 billion$\cdot yr^{-1}$. Within the same period a 50% reduction in deforestation would save \$17.2 billion to \$28 billion yr^{-1} by reducing 1.5 to 2.7 Gt CO_2 yr^{-1}. Over the past three decades climate change has caused major changes in the distributions and abundances of global

biodiversity (Vitousek, 1994, Hughes, 2000). Thomas *et al.* (2004) predicted on the basis of three climate warming scenarios including minimal-range, mid-range and maximum-change scenarios about 18%, 24% and 35% of species are likely to be extinction, respectively.

2.1.2.3 Disaster prevention

This service refers to the ability of ecosystems to provide protection against natural hazards. For instance, wetlands, forests and coastal systems, act as natural protective barriers against floods, landslides, storms, wildfires and avalanches (de Groot *et al.*, 2002, Brander *et al.*, 2013, Thomalla *et al.*, 2006). In the European Alps, there is a long history of managing mountain forests to provide protection against rock falls and avalanches (Dorren *et al.*, 2004). In Switzerland, collaborative forest management approaches have also been adopted to reduce such natural hazards (MacKinnon *et al.*, 2011). In Argentina, it has been shown that conserving forest ecosystems is a low-cost yet effective way to protect against floods, as well as provide biodiversity benefits (Emerton *et al.*, 2003).

Ecosystems also lessen disaster risk by sustaining local livelihoods and providing essential goods such as wild food, medicinal recourses, and construction materials, which are vital to strengthen human resilience and security against disaster impacts (Costanza *et al.*, 2014, Akwetairehoa and Getzner, 2010, Salafsky and Wollenberg, 2000). Mangrove forests play a crucial role in coastal development and the establishment of surrounding communities. Mangrove forests growing along the coasts supply a number of services such as reduced storm damage, coastline erosion prevention, reducing pollution, and supplying subsistence resources including food, traditional medicines, and shelter (Osti *et al.*, 2009, Costanza *et al.*, 2008). The role of mangrove forests in protecting people from

tsunamis, especially the 2004 Boxind Day tsunami, is widely mentioned in the many studies. Yanagisawa *et al.* (2009) found that *Rhizophora spp*. forest with a 0.2 trees m^{-2} density and a diameter of 15cm in a 400m wide area can reduce up to 30% of inundation depth during tsunami.

2.1.2.4 Water regulation and supply

Water regulation represents the influence ecosystems have on the hydrological cycle of the planet. This ecosystem function differs from 'hazard prevention' as it refers to the maintenance of the 'normal condition' of watersheds and ensures the maintenance of natural irrigation and drainage, as well as the regulation of the channel flow to support water transportation (de Groot *et al.*, 2002). Forest ecosystems in watersheds regulate water flows in rivers and streams and there is a growing recognition for water regulation services of forests in local watersheds resulting substantial economic gains to human societies and development downstream. For example, the benefits of water flow regulation by the forest ecosystems upstream stretches over rivers, cities and farmlands are well recognised (see Figure 2.1) (Guo *et al.*, 2000).

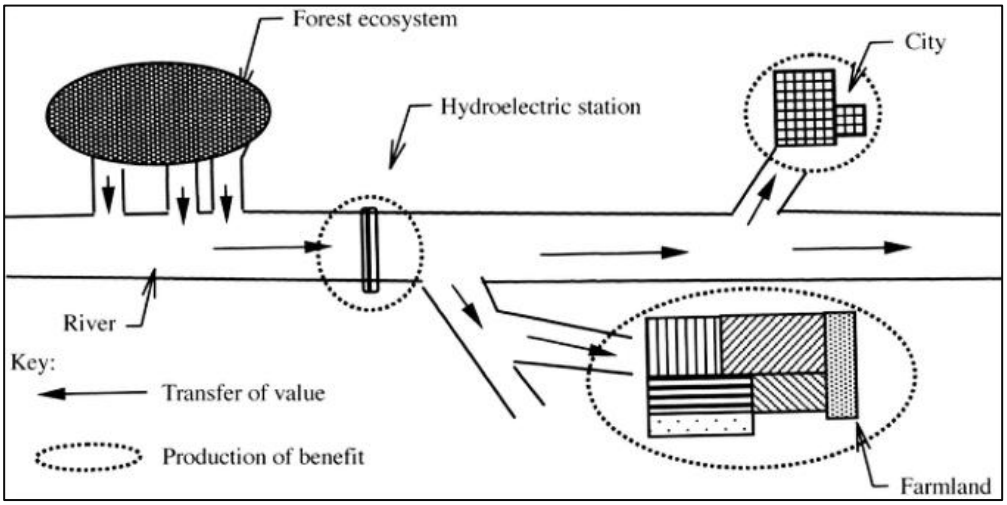


Figure 2.1: Transfer of services of natural ecosystems to the human development (Guo *et al.*, 2000)

Within this context, vegetation and soil biota act as filtering agents of water and storage is influenced by the topography as well as sub-surface features of the ecosystems. Water supply benefits include improving the availability of cleaner water for households, agriculture and industrial production (de Groot *et al.*, 2002). Due to the growing focus on global climate change, the hydrological and meteorological importance of forests has attracted much attention worldwide. Water supply function of forest ecosystems provide astrong argument for their sustainable management (Calder, 2007, Andréassian, 2004). Large volumes of fresh drinking water come from the catchments found under natural or artificial forest cover. Thus, there is a direct relationship between forest cover and quality of water of the catchments. It is also evident that the volume of water yield from a catchment largely depends on the forest structure and age. Therefore, forest ecosystem management around the watersheds provides a fundamental basis for sustainable watershed conservation (Dudley and Stolton, 2003).

It has been estimated that ecosystems provide water regulation and supply services worth US$ 2.3trillion/yr globally (Costanza *et al.*, 1997). In China alone this is estimated to be 7.5 trillion yuan, which is equalto three times the value of wood resources (Athanas and Vorhies, 2001). Similarly, it is reported that Mount Kenya forest saved more than US$20 million in the national economy by protecting the catchment area for the Tana and the Ewaso Ngiro, two of the country's main river systems (IUCN, 2001). Policy makers should thus be required to consider such information when implementing programs to support the sustainable management of catchment areas thereby addressing some of the important social issues associated with the services provided by the ecosystem (Dudley and Stolton, 2003).

2.1.2.5 Soil retention

Although not necessarily the case for all ecosystems, soil erosion is a widespread concern in many ecosystems due to the adverse effects it has on agriculture land, forest and aquatic ecosystems. For that reason, soil erosion is one of the most important environmental problems in the world and can create long-lasting damage in both local and global scales (Pimentel *et al.*, 1995). Erosion of soil occurs when raindrops hit exposed soil and result in splash and sheet erosion, two most common forms of erosion (Bochet *et al.*, 1998). Increasing vegetation helps prevent such soil loss as well as controlling runoff and sediment control, and hydrological process regulation (Yu et al., 2013). The litter, roots, and canopy cover slow down the soil loss process and increase the amount of interception and soil infiltration capacity and decrease raindrop impact on the soil surface (Naylor *et al.*, 2002, Wainwright *et al.*, 2000, Rey, 2003). Holifield Collins *et al.* (2015) also showed that the runoff and sediment yield were correlated with canopy cover.

The structure of a forest ecosystem including the vegetation cover and root system of its plants influence soil retention capacity. Foliage intercepts rainfall and tree roots stability the soil thus prevent the bare land surface from both erosion and compaction. For example, vegetation cover along the coast-line greatly control erosion and facilitate sedimentation (de Groot *et al.*, 2002). Soil loss not only affects on-site soil quality, it also can have serious consequences in downstream areas. Soil loss also diminishes water quality, accelerate siltation of dams and irrigation channels in both on-site and off-site areas (Cruz *et al.*, 1988, Asselman *et al.*, 2003, Henley *et al.*, 2000).

2.1.2.6 Soil fertility

The most important nutrients for plant growth are nitrogen, phosphorus, and sulphur. In addition, nutrients such as calcium, potassium, magnesium, chlorine, and sodium are also essential for forest ecosystems to thrive. Moreover, numbers of trace elements are required to maintain vegetation growth including iron and zinc that provide physical and morphological support to the plants in order to facilitate internal recycling of nutrients. For example, soil organisms make nutrients available to the plants by decomposing organic matters (de Groot *et al.*, 2002). The availability of phosphorus to the plants is maintained by phosphorus cycling occurred due to the competition among plant roots, microorganism, soil minerals and organic matters. It is well established that many plant species can exude compounds from their roots which can solubilize phosphorus sources during low availability (Attiwill and Adams, 1993).

2.1.2.7 Pollination

With the exception of some plants including tubers and root crops, pollination is essential for almost all plants to reproduce and many wild pollinator species deliver this service including insects, birds, and bats (Klein *et al.*, 2007). Without these animals, many plants would disappear and cultivation of most agricultural crops would not be possible. Moreover, without a healthy population of the wild pollinators, achieving agricultural production growth would be enormously costly (de Groot *et al.*, 2002). Lack of a healthy number of pollinators would worsen the situation food and nutrition security of world population especially of the millions of people in developing countries (Smith *et al.*, 2015, Roy *et al.*, 2006).

Advanced agriculture and forest land clearing pose great threats as they endanger pollinator communities directly which would eventually destabilize our food production.

In several parts of the world population decline of native bees have already been a major agricultural concern (Biesmeijer *et al.*, 2006). Wild pollinators are required to be conserved to sustain the pollination services for the sake of maintaining productive agriculture landscapes. These include habitat conservation (e.g. forest vegetation, soil substrates etc.) and support pollinators by ensuring enough nectar production (Klein *et al.*, 2007).

2.1.2.8 Biological control

Evolutionary processes have been occurring for millions of years and have enabled biotic communities to develop many interactions and feedbacks which eventually bring stability to the earth (de Groot *et al.*, 2002). Rising CO_2 concentrations in the atmosphere is known to reduce precipitation by 20% as it impacts the stomatal opening and closure of forest leaves. Dieback disease is another phenomenon creates a positive feedback in reducing precipitation by suppressing local evaporative water recycling through reducing forest vegetation cover and releasing CO_2 in the atmosphere. It is estimated that dieback disease can reduce precipitation by 25% in total as result of biogeophysical and the carbon cycle feedback (Betts *et al.*, 2004).

The wildlife found within a forest ecosystem plays a vital role in soil formation and nutrient cycling. Herbivory returns nutrients to the soil in the forms of dung, urine, and litter facilitating the growth of soil biota and enhance mineralization and thereby increase plant productivity. Additionally, the activities of herbivores on the surface can accelerate nutrient supply to plants by influencing the physiological function of plants e.g. root exudation. These mechanisms, together, can benefit the ecosystem production. On the contrary, low soil fertility of an ecosystem would reduce the presence of herbivores due to the production of lower quality plants. Thus changes in either the herbivore population

(through hunting for example) or the soil quality (through tree removal, for example) would cause a vegetative change in the forest that would alter its entire structure. As a result, the whole ecosystem would suffer from lower levels of biotic activity including changes to mineralization of nutrients, and consequently lower productivity of the ecosystem. While an unproductive ecosystem can create some localized positive feedback, these changes do not outweigh the benefits of enhance plant productivity in an intact ecosystem (Bardgett and Wardle, 2003).

2.1.3 Cultural services

2.1.3.1 Aesthetic value

People enjoy the scenery of natural landscapes of wild ecosystems and people prefer living in aesthetically pleasing environments. This value has considerable economic importance in deciding the economic price of land or houses (Costanza *et al.*, 1997). The affinity of humans to greenery is an age-old phenomenon and the desire to recreate green landscapes and living around them is universally desired. Every liveable and sustainable city offers ample green areas to both residents and visitors. In modern urban design, amenities and recreational opportunities have been well recognized as a key service offered to the citizens by the urban green spaces. it is highly desired to have green areas in the city and residents are often willing to pay directly or indirectly to maintain the services (Botkin and Beveridge, 1997, Lorenzo *et al.*, 2000).

The innate beauty of neighbouring parks to a certain extent determines the justification for their existence and benefits to deliver to surrounding communities. Natural ecosystem, either purely natural or created artificially to resemble nature, provides an aesthetically pleasing view and is at a premium in urban areas. A lucrative design and well-maintained park in a neighbourhood can significantly improve the wellbeing of the

citizens (Jim and Chen, 2010). Although urban parks are generally limited in size due to scarcity of land, their contributions in creating a healthy living standard is very crucial for the urban residents (More *et al.*, 1988).

2.1.3.2 Eco-tourism

Natural ecosystems serve as the place where people can relax and refresh by offering opportunities for hiking, walking, camping, fishing, and swimming. Eco-tourism has thus recently become a massive industry which should continue to grow in the foreseeable future (de Groot *et al.*, 2002). Within the new array of 'green' products and services, ecotourism claims a strong position to generate environmental as well as economic benefits to incentivise conservation efforts. Economic incentives are imperative for nature conservation, especially in remote and poor regions where an inadequate presence of the state hinders the benefits of alternative environmental regulation tools (Wunder, 2000).

Community Based Ecotourism (CBET) has become a popular approach for conserving biodiversity, as an ecosystem with a high-biodiversity value is potentially capable in creating employment opportunities and generating income for the surrounding marginalized people (Stronza, 2007). Despite many successful examples in producing revenues for local communities and improving their attitudes towards conservation, CBET contributions to biodiversity conservation and local wellbeing remian limited due to a lack in proper revenue distribution, inadequate local participation, smaller commercial success and the competitive nature of the tourism industry (Afenyo and Amuquandoh, 2014, He *et al.*, 2008, Ezebilo and Mattsson, 2010). Thus, many CBET projects identified as 'successful' has actually have little impact on existing resource-use, as they generate only a small or moderate income boost to local families (Kiss, 2004).

Ecotourism has also served to connect many indigenous communities to market which otherwise would be impossible (Campbell, 1999, Johnston, 2000). Ecotourism may therefore work as a catalyst for uplifting the local economy as well as provide households a wider range of income opportunities (Levy and Lerch, 1991). Ecotourism unlike other types of tourism can make a big difference in local livelihood as the sites are generally in remote areas where there are little income opportunities and poor market facilities available for the local people (Wunder, 2000). A small increase in income tends to impact poor households greatly than rich families (Stronza, 2007).

2.1.3.3 Cultural, spiritual and inspirational

Natural ecosystems are often the main source for creating folklore and culture as humans have developed by interacting with nature. Numerous books, magazines, fairy tales, films, photographs, paintings, sculptures, music, architecture etc., would not be possible in the absence of natural ecosystems. Unfortunately, these services are often intangible and hard to quantify in reality (de Groot *et al.*, 2002).

There are many spiritual values generated from nature especially among the indigenous communities such as worshiping a forest, tree or animal are the rituals inspired by nature (de Groot *et al.*, 2002). Baima Tibetans, a unique ethnic group have been living in the hilly areas of Gansu Province has the rich traditional knowledge and follow many ancient religious beliefs. All of their beliefs, customs and knowledge are the results of their ways of living in the hilly ecosystem. These ethno-cultural features created multiple effects in the area such as protecting the iconic panda and other biodiversity, creating a great sense of self-identity, and enhanced their livelihood security (Luo *et al.*, 2009).

2.1.3.4 Scientific and educational information

Ecosystems offer endless opportunities for natural and environmental education through research, excursions and setting up onsite laboratories. This provides opportunities to generate valuable academic and non-academic knowledge (de Groot *et al.*, 2002). Thus in order to sustainably management of our planet', Environmental and Natural Resource Economics has emerged as a popular area of study over the past three decades. Its brief history to date provides a context for the explorations of future research opportunities to follow (Deacon *et al.*, 1998). In the past 20 years, a remarkable advancement has been made towards understanding consequences of biodiversity loss on the functioning of ecosystems and human society. Immediately after the Rio Earth Summit in 1992, interest in exploring how biodiversity loss might affect the dynamics of ecosystems, and the production of ecosystem goods and services has grown rapidly. Major international research initiatives are underway; hundreds of experiments are performed in ecosystems all over the world to develop and test new ecological theories (Cardinale *et al.*, 2012).

In addition to the proliferation of experiments, biodiversity research has developed a substantial body of mathematical theory (Cardinale *et al.*, 2011, Tilman *et al.*, 1997, Kinzig *et al.*, 2001). Rapid proliferation of data has resulted in six formal meta-analyses of the biodiversity and ecosystem functioning literature between 2006 and 2008 (Balvanera *et al.*, 2006, Cardinale *et al.*, 2006, Cardinale *et al.*, 2007, Cadotte *et al.*, 2008, Stachowicz *et al.*, 2007, Worm *et al.*, 2006). These meta-analysis has boosted the number of biodiversity research and created an exponential growth in manuscript publications in this field (Cardinale *et al.*, 2011).

2.2 ESS valuation

ESS valuation is a method by which we can assess the contributions of the ESS that are essential to maintaining human wellbeing and sustainable development (Liu and Costanza, 2010, Liu *et al.*, 2010). In the last three decades, the valuation of ESS has become one of the fastest developing research areas in the field of environmental science disciplines (Turner *et al.*, 2003). As listed above, humans benefit from natural ecosystems in many different ways. In the face of growing human pressures on the natural environment, these services are powerful justifications for sustainable conservation of these ecosystems (Balmford *et al.*, 2002). However, typically only those natural goods and services that have a direct monetary value (e.g. food, fibre, wood and water) are recognized by the neoclassical economy, with the more intangible benefits such as soil protection, disaster control, water purification or habitat provision going largely ignored, possibly causing irreversible losses (Carreño *et al.*, 2012).

Solow (1956) developed a production function under an assumption that the contributions of nature can be neutralized by using capital and labour arguing that scarcity of a particular input of a resource increases production cost and then consumers move to low-price alternatives. This price-demand relationship eventually allows rejuvenating that particular recourse. It is also suggested that including 'land' as a variable in the production function eventually leads to decreasing marginal return (Solow, 1973). Shortly after Solow (1974) reiterated stating that if the substitutes to the factors for natural resources are easily available, in principle, there will be no problem to get along without input from natural resources; hence, resource exhaustion is not a catastrophe, it is mere an event. This kind of classical economic theory led the world's development and the trend continued until the middle of 20th century, the starting period of the proliferation of modern environmentalism. Since then, specialized economic disciplines have been

started to address the environmental issues along with the standard economic theories (Gómez-Baggethun *et al.*, 2010). Environmental and Resource Economics as a discipline widens the scopes of neoclassical economics by introducing the methods to asses and internalize the impacts of economic development on our environment. A neoclassical approach of economics inherently neglects the economic contributions of natural ecosystems by excluding the goods and services of nature that do not bear a direct market price. Hence, the systematic underestimation of ecological contributions in policy decisions has been continued partly because natural capitals are inadequately quantified compatible with the other economic benefits and built capitals (Costanza *et al.*, 2011, Costanza *et al.*, 1997).

In order to capture a more comprehensive value of nature, identifying all the economic contributions are essential; especially those which are neglected by conventional pricing tools (Gómez-Baggethun *et al.*, 2010, Daily *et al.*, 2009). MEA (2003) has successfully started the process and since 2003 many studies have further improved the classification of ESS (Pascual *et al.*, 2010, Wallace, 2007, Fisher *et al.*, 2009, Fisher *et al.*, 2013, de Groot *et al.*, 2002). Notwithstanding the advancement in identifying ESS, the techniques used to value ESS have remained a matter of debate since its inception. Moreover, the concept of ecosystem services is conceived merely as a communication tool, and valuation exercises are interpreted as a language in communicating the value of our ecosystems (Daily *et al.*, 2009). Short term or long term whatever the debate is, the valuation can potentially halt ecosystem loss where conventional notions of conservation have failed to compete the economic decision making (De Jong *et al.*, 2000). The integration of ecosystem services with economic theories can provide policy and decision makers a wide spectrum of options for making the development activities more sustainable (Fisher *et al.*, 2008).

2.2.1 Ecosystem valuation methods

The core idea of valuation of the benefits of nature is complex and multi-dimensional in nature. Economists generally strive for a taxonomy of different types of environmental value which represents total economic value. The key difference made in defining the value of nature is between the use values and non-use values which implies we may have little or no use for a given set of environmental resources but would experience a loss if the resources are diminished (Turner *et al.*, 2003).

2.2.1.1 Direct market valuation methods

- **Price method:**

  This refers to the exchange values that ecosystem services have in the market, primarily applicable to the 'goods' (Powicki, 1998). This method is often used to generate the value of provisioning services, as the commodities produced by the ecosystem have a market value for trade. In a functioning market consumers' preferences and marginal production costs determine the market price, which is considered as the reliable information on the value of commodities (Pascual *et al.*, 2010).

- **Cost method:**

  - Avoided Cost (AC): These are the costs that services save society by avoiding the costs that would otherwise be incurred in the absence of the ecosystem. For instance, flood control (by avoiding damages to property) and waste treatment (by avoiding health expenditure) by wetlands (de Groot *et al.*, 2002).

- Replacement Cost (RC): These are the costs associated with the creation of artificial man-made systems to replace the services of a natural system. For instance, the waste treatment services provided by marshes can partly be replaced by installing expensive artificial treatment facilities (de Groot *et al.*, 2002).

- **Production method:**
  - Factor Income (FI): Many ESS enhanced revenues by acting as natural inputs to other production system. For example, water purified by nature systems increase income of fishermen by increasing the amount of fishes available due to better water quality (de Groot *et al.*, 2002).

2.2.1.1.1 Limitations of direct market valuation

Direct market valuation predominantly relies on the market value of ESS, which are often readily available. However, applying the values in ESS valuation are sometimes criticised especially when there is no market for the services (Kumar, 2010) because if there is no market for the service or for a closely related service there is no data to base valuations on. Even if the market exists, any subsidy scheme would not represent the true value of the product. Eventually, the estimation the value would be biased and will not be reliable in important policy decision (Kumar, 2010, Baker and Ruting, 2014).

In addition, the production function of an ecosystem is yet to be understood well enough to answer the two following major questions: 1. how many services are produced by an ecosystem, and 2. how changes to an ecosystem affects the service production (Daily, 1997). Moreover, a continuous debate exists across the scientific community to reach universally accepted and consistent classifications of ecosystem services (Wallace, 2007, deGroot *et al.*, 2010). Along with this, enormously complex interactions in the

ecosystems and lack of knowledge on the dependence on the ecosystem in spatio-temporal scale often cause double counting (deGroot *et al.*, 2010, Fu *et al.*, 2010).

2.2.1.2 Revealed preference methods

- **Travel Cost (TC):**

The travel cost method is commonly used to determine the consumer surplus associated with travelling to a recreational site including parks, beaches and heritage sites (Hailu *et al.*, 2005). These travel costs are a reflection of the indirect value of the service. It refers to the travel expenditure during a trip as a substitute price travellers pay for sites recreation or the service (Liston-Heyes and Heyes, 1999). There are two most widely used travel cost models are single-site model (SSM) and random utility model (RUM). The RUM provides an individual with a full set of alternative sites to choose. It allows for different types of tastes in a lot of ways (Murdock, 2006).

- **Hedonic Pricing (HP):**

Hedonic pricing is the idea that sets prices placed on the values of the attributes of a commodity indirectly affects its market price and thus can help to determine the implicit price of non-marketed attributes. For example, housing prices at beaches are at very high premium compare to the identical inland homes with less attractive surroundings (de Groot *et al.*, 2002).

2.2.1.2.1 Limitations of revealed preference methods

Market failures and policy imperfections can mislead the estimation of ESS in revealed preference methods. It requires accurate transaction data, large data sets, and complex statistical analysis. Generally, these methods rely on the technical assumptions made

about the relationship between the surrogate market and environmental goods (Whitehead *et al.*, 2008). In hedonic pricing, the estimations remain limited to the benefits that are related to housing prices. Thus, if people are unaware of the relationship between the environmental features and their effects, then the value would not reflect the actual price of the services (Mavsar *et al.*, 2014). Travel cost methods are also subject to less reliable valuation because of the inability to identify the change in recreational demands over time due to the quality change (Whitehead *et al.*, 2000).

2.2.1.3 Stated preference methods

- **Contingent valuation (CV):**

  This refers to a Willingness to Pay (WTP) for the availability or Willingness to Accept compensation (WTA) for the loss of respective services. Since the 1960s, it has been the most commonly used technique for non-market services valuation. Its high level of flexibility allows valuation of a wide range of non-market goods without paying the price. Non-use values, also defined as "passive use" values, refer to the values that are not subject to actual use of the resources (Carson *et al.*, 2001).

- **Choice modelling (CM):**

  This involves asking respondents about various alternative types of a good, classified by their attributes and levels, to rank them. By including price/cost as one of the attributes, willingness to pay can be indirectly obtained from people's choices (Hanley *et al.*, 2001, Mogas *et al.*, 2006). For instance, an alternative could be described as h-hectare of an additional forest with x-percentage of a tree species, costing d-dollar. One of the alternatives in each choice set describes the

current or future situation without any major change, and remains constant in the preference sets. The CM method can potentially estimate the values for available alternative options and marginal changes due to the individual characteristics (Othman *et al.*, 2004).

- **Contingent ranking (CR):**

In a CR method respondents are requested to rank the preference of environmental goods from a discrete set of hypothetical alternatives (Caplan *et al.*, 2002). The trade-offs between their preferences and the attributes can then be used to generate the marginal utility of an individual attribute. As price/cost is included as one of the attributes, it is possible to generate WTP estimates for particular bundles of attributes. This ranking approach is especially useful in estimating the values of environmental programs which has several different components associated with it (Garrod and Willis, 1998, Foster and Mourato, 2002).

- **Deliberative group valuation:**

In deliberative valuation, a range of techniques are employed to stimulate deliberation and to establish social willingness to pay for policy options through deliberation and negotiation. A small representative group of selected persons find out the values guided by collective decisions through reasoned discourse. It is argued that deliberative techniques facilitate public participation and thereby enhance the effectiveness and perceived legitimacy of policy decisions (Howarth and Wilson, 2006). Deliberative Monetary Valuation (DMV) is often described as a 'hybrid' analytical deliberative method. By integrating scientific or technical

forms of analysis with deliberation process, both facts and values can be made more transparent (Fish *et al.*, 2011).

2.2.1.3.1 Limitations of stated preference method

Stated preference methods often suffer from a hypothetical bias, lack of meaningful budget, and strategic and information biases (Arrow *et al.*, 2001, Baral *et al.*, 2008). For example, CV respondents often answer without thinking carefully about how much disposable income they have available to allocate. They also increase or reduce the value without any standard guidelines, as in many cases people do not understand the complex nature of environmental services (Arrow *et al.*, 2001). A long-standing criticism with stated preference method is that this method is rather easy and careless activity to the respondents in valuing environmental services. Many critics argue that measuring preferences by asking survey questions only is associated to the violation of economic theory to some extent and thereby this approach is likely to produce inaccurate data (Carson *et al.*, 2001).

2.3 Access to Ecosystem Services

The complexity of ESS stretches from just the value of the services into the area of how to obtain and maintain access to them. The issue of having access to the benefits emerged from a growing plea for the sustainable use of natural resources (Berkes, 2004, Ameha *et al.*, 2014). Access to natural resources such as forest, water and land is crucial for sustainable rural development. Because, without secured access to natural ecosystems the poor, particularly landless, people face more difficulties in accumulating required assets to meet their demands and recovering from any environmental shocks (Ellis and Allison, 2004).

Community forestry, an approach that recognises people's access to forest goods and services has gained the attention of the policy makers for forest conservation in order to improve rural wellbeing (Nath and Inoue, 2009, Thoms, 2008). It is argued that devolution of power to local communities will ensure equitable and inclusive management outcomes. However, many studies suggest that community forestry programs in many parts of the world in fact create unequal access to the forest (Adhikari, 2005, Beck and Madan, 2000, Baynes *et al.*, 2015, Stephen R. Kellert, 2000). Irrespective of the management practices, equitable access of local people to the benefits from different forest management approaches has undoubtedly received great attention because of its crucial role in achieving sustainable ecosystem management goals (Daw *et al.*, 2011, Ellis and Allison, 2004, King, 2011).

Access to forests is sometimes referred to as 'property rights' and thus it is often assumed that granting adequate rights will lead to greater wellbeing. However, Ribot and Peluso (2003) have argued for a conceptual uniqueness of "rights" and "access" by stating that access is all about available assets or means by which a person becomes able to benefit from anything; this includes different institutions and socio-economic factors that allow or obstruct the flow of benefits from any resources. On the contrary, 'property' deals with legal or customary claims which is only one of the factors determining resource-user's ability to benefit from a resource (Maryudi and Krott, 2012, Ribot, 1998).

The earth's ecosystems sustain our wellbeing by supplying many services. Yet the communities dependent on the services are mostly poor and underprivileged because they are often unable to utilise the resources to their greatest potential. As their wellbeing is heavily tied to the supply of the services and alternative options are often unavailable, it is important to maintain the access of these people to the resources. Especially, they often do not have any other ways than extracting the resources and thereby engage in

overexploitation and illegal activities. Forests provide a key income source for millions of poor people who have limited livelihood options (Vedeld *et al.*, 2007). For example, in Nepal forests are the ground for both grazing and fodder collection for the livestock. These livestock produce manure that is used to fertilize fields and are the primary source of milk and meat to feed people. More than 80% of the total household energy consumption in the country is derived from fuelwood (Sharma, 1996).

2.3.1 Different ways of access

2.3.1.1 Access through law

This is broken down into legal access and illegal access. Legal access is obtained through state laws and policies. This thus involves a community, state or government that enforces the claim via titles, permits or licenses (Tawney, 1978). Customary or traditional access can also provide legal access and happens by social acceptance or traditional practice (Weber, 1978). Property rights holders can assert sanctions to control access. But those do not have such rights must gain access by paying a fee or exchanging any service to rights holders. Thus, the property rights per se, shape the relations across the society with respect to benefit flows (Ribot and Peluso, 2003).

The law plays an important role in shaping access to the resources. In many parts of the world law enforcing authorities are corrupted. The individual or organization who has privileged access to the institutions can influence the laws and policies in favour of him/them. For instance, in most parts of the Amazon up to 90% of logging activities are illegal but the central government put a blind eye on this (Seneca Creek Associates, 2004). Ecosystem dependent communities are mostly engaged in small-scale harvesting of resources. They are often unable to communicate with the public office to get the benefit of laws and policies, thus the access gets restricted. On the other hand, large

industries can easily go through all the bureaucratic process to get access and many cases illegally limit the access of the local people (Obidzinski *et al.*, 2014).

Different authorities may also have overlapping jurisdictions of authority that can create conflicts among them. This provides opportunities to groups or individuals to acquire resources by legitimate or authoritative access (Gupta and Siebert, 2004, Amacher *et al.*, 2012). Generally forest is managed by the forest department/administration, but to prosecute the person in illegal activities they need to depend on police or local administration (Ghate *et al.*, 2009, Muhammed *et al.*, 2008). Moreover, NGOs are often involved in conservation program which is also been monitored by various departments (Ebeling and Yasué, 2009, Tacconi, 2007). Hence, interests of all the departments make a complex mixture of jurisdiction and allow limited to access to the resources. However, despite all the complex rules and regulations, local people continue their traditional activates in the ecosystems either legally or illegally (Tacconi, 2007, Shackleton *et al.*, 2002).

Social structure and institutions including traditional authority and rituals are considered important in maintaining this functional adaptation of community members (Leach *et al.*, 1999). Institutions are combinations of practices, and rules and regulations that decide user behaviour in enjoying any resource. Therefore, institutions are not enough in shaping resource management outcomes; instead, it is required to specify the sets of rules and actions in a given context. Moreover, it is often difficult to identify which structure of the institutions will be appropriate in managing certain resources (Agrawal and Yadama, 1997).

A contradiction is common in laws, policies, customs, and traditions. Laws created by the same government in an identical period of time are often a source of conflicts. Moreover, sometimes new policies or laws result in a lack of inclusiveness of all parties. For

example, in collaborative forest management, all the rights of the parties are not clearly delineated and many legitimate stakeholders are excluded. In theory, this management approach is supposed to engage dependent communities but most of the cases failed to transfer the rights to the stakeholders (Larson *et al.,* 2008). These ambiguities ultimately keep state's control over the resources. The policies of participatory approach are to be approved by a minister or chief administrator and then it comes to the people on the ground, thereby, the power to allocate access remains in the hand of public officials and leave the resource users in a position to maintain the access by investing their capitals (Ribot, 1995). Discrepancies also cause overlapping rights or legitimacy where legal and customary rules are used to gain access. Within these formal as well as informal pluralism, the state still holds the ultimate control and power to decide access. Nevertheless, some stakeholders find the ways to maximize their benefits by securing their own access or getting control over other's access due to their ability to be engaged with the groups from which they gain the power.

Despite the sanctions of customs, tradition or law some actors gain access by ignoring the rule of law. This type of access is operated by coercion and stealth that shape the relations among actors. Access is controlled illegally by the legitimate or illegitimate authorities and people maintain by nurturing relations with those who control the access. Government officials may use the power for their personal gain by allowing illegal activities in a protected ecosystem. Those who can maintain their illegal access may either bribe officials or use political influence achieved by being in close connection with local leaders. This often results in marginalised people becoming the victims of prejudice and not receiving access to land. This demonstrates that legal means are not always the way to gain access.

Robbins (2000)shared a story of illegal access as follows:

> *"At the fringes of a deciduous forest, on the edge of a savannah plain, a local landlord sits in the shade of his courtyard, sharing an unlabelled bottle of hard liquor with his neighbour, a lower-level guard from the state forest department. The bottle is finished, and later that evening, some eighty or ninety trees are noisily felled by paid workers in the adjacent wildlife sanctuary and carted back to the landlord's farm by tractor to be later sold at a dramatic profit on the regional timber market." (p. 243).*

In many parts of the world where extra-legal financial exchanges (e.g. bribe and other benefits) allow illegal activities to happen is more the rule than the exception. Whether in the tropical timber trade in Cambodia (Milne, 2015), allocating urban land in China (Cai *et al.*, 2013), referring patients to private hospitals in the UK (Godlee, 2015), or the disposal of medical waste in New York (Carter, 1996), corruption is everywhere, and often an organized and powerful system to govern the use of natural resources.

2.3.1.2 Access by technology

In many cases, technological requirements mediate access to ecosystems. For example, the collection of numerous resources may require machines or technologies, leaving those that have advanced technology to benefit. Indirect possession of technology also facilitates the ability to reach resources. For example, access to tube-wells or pumps can allow people to use groundwater and determine who-else can use it. New technology in non-tradable production removes barriers for poor producers and assists them in gaining income and market shares (Dorward *et al.*, 2003). Adoption of new production technologies in developing countries is determined by a wide range of economic, physical and social factors (Nkonya *et al.*, 1997).

Based on the adoption rate, introducing new technology in the rural areas generally has achieved only partial success. The traditional practice is a constraint to the rapid adoption of innovations primarily due to the lack of capitals, insufficient information, perceived risk, inadequate incentives, and poor infrastructure (Feder *et al.*, 1985, Pannell *et al.*, 2006, Mendola, 2008). Thus modern technology may have a more devastating effect on the livelihoods of the poor while maximising the advancement of the wealthy (Mendola, 2008).

2.3.1.3 Access by money

Possessing an adequate amount of money is a strong manifestation of a one's ability to benefit from any resources. However, access by money not only increases a person's financial ability through increased production and consumption, but it also can be used to buy rights that can give the power to control or maintain access to the resources (Ribot and Peluso, 2003). Resource extraction largely depends on the financial capitals of the local people. Communities dependent on ecosystems are often marginalized and vulnerable. They largely depend on the wealthier part of the society to maximise their benefits. Richer households are thus the traders who supply capital and tools to other people who continue the flow of resources to trade. This informal trading relation locks the people in agreement with the traders to sell the products to them. The price they receive from the traders is often exaggeratedly lower than the actual market price. Even if an ecosystem is managed in collaboration with local people, wealthier or richer households can make the most out of this. For example, community-based tourism often attracts outside investment for associated hotels, resorts, and tour package. These businesses all earn revenue, leaving the local people who may work as CBET guides, helping hands, or cooks, to earn disproportionately lower than the rich (Nguyen, 2006).

In Wolong Nature Reserve for Giant Pandas (China), local residents, primarily affected by the conservation program, receive only a small portion of the total benefit, while the majority of economic benefits go to other wealthy stakeholders. Moreover, the rural families who benefit from ecotourism are the people living near the main road and potentially have more financial capability than the households closer to reserve households but far from the road (He *et al.*, 2008). The benefit distribution gap is likely to discourage marginalized households in supporting conservation efforts who are livelihood activities are considered as the main drivers in degrading panda habitats. The unequal distribution of the benefits from ecotourism reduces the access to economic benefits of the deserving families. At the same time, the investors put further control in access to the forest to maximize their benefits by restricting subsistence activities of poor people (Stronza and Gordillo, 2008, Afenyo and Amuquandoh, 2014).

2.3.1.4 Access by the market

One of the problems for ecosystem dependent communities is inadequate access to an established market. Market access is the ability to gain control and maintain provision in the exchange relationships. Markets also influence the access to the benefits in many ways. The values of ESS may fluctuate when natural resources are commodified or when traders get involved in doing business with the services. Candlenut trees are wild in West Kalimantan forests and are not used by the local villagers. Javanese migration in West Kalimantan, however, created a market as candlenut is an important ingredient of Javanese cuisine. Thus, all of a sudden the villagers started to take care of the plant through swidden cultivation which impeded access of others i.e. they only declared their access to a resource when a market value for the product emerged (Ribot and Peluso, 2003).

Supply and demand for a product can be raised in other locality or international market. In that case, control of access is more complex and local residents have substantially less influence on the flow of the product. Many ecosystem resources are illegal to harvest which created a huge black market that generates high income for the locals (Ayling, 2013, Shanley *et al.*, 2002). This kind of market is controlled by a small group of people and thereby market access of the marginalized people are again heavily relied on the influential people (Cerutti *et al.*, 2013). Market-based instruments of natural resources governance have been promoted in recent decades to lead greater environmental benefits and ensure fair benefit distribution. Marine Stewardship Council (MSC) certifies 'fish from sustainable sources'. MSC has successfully created awareness for 'sustainable fish'. But Ponte (2012) argued that MSC has marginalized Southern fisheries, especially in low-income regions. This eventually reconfigured the whole access mechanism for marine fish.

2.3.1.5 Access to information and knowledge

Many environmental resources are used for more than just economic reasons; they also serve socio-cultural purposes. In Borneo, durian has both a monetary exchange value and an inheritance value as trees are owned and passed on through families. Another way it is accessed by the people based on the location of the tree and the communities. Trees are identified in different names according to the historical events associated with it. Therefore, cutting these trees is subject to recognition of ancestral claims and cotemporary villagers (Peluso, 1996).

Expertise acquired through training, higher education or titles can give an individual privileged access to employment opportunities, groups and networks and physical access to resource harvest. Knowledge and information also play key roles in securing authority over individuals and groups to control others' perceptions and ability to benefits from the

resources (Ribot and Peluso, 2003). Scientific findings to assess the effects of human activities on ecological degradation often purposively justify the state control and local people's prohibition. But participatory forestry approach is asking forestry authorities to recognize the local people as important stakeholders as well as ease the grip on the natural ecosystem (Salam *et al.*, 2005, Kibria *et al.*, 2014, Safa, 2004). Control over the information and knowledge plays a vital role in securing benefits from the resources. In the rural areas, ecosystem-markets are generally informal institution, and producers have not been informed the actual market price of the products in national and international markets in order to keep the producer price at the minimum. Technological extension in the rural areas can play a pivotal role to improve the local livelihoods by giving them access to the market information. For example, mobile phone possession may allow households contact the traders directly to know the market price of the product they collect, depending on the local merchants instead, and thereby maximize their benefits from ecosystems (Wyche and Steinfield, 2016). This eventually can have reciprocal effects on ecosystem conservation and local livelihood as a whole.

2.4 Livelihood capitals and access

2.4.1 Human capital-access

Human capital included the knowledge, skills, and good health condition that enable humans to pursue different livelihood activities. At the household level, these are the factors of the quality and quantity of labour. Ill health and ignorance are often considered as the core dimensions of poverty; hence, overcoming these are the primary goals of many rural communities.

Support to improve human capital can be achieved by either direct and indirect measures or combination of both. The best way forward is through an integrated approach adequately focused on the most needed parts of the society. Training is an essential part

of human capital as it fills in the gaps of lacking formal education. But the knowledge must be relevant to the existing or future livelihood activities and provision must be ensured to the knowledge (DFID, 1999). Status of available labour in a family such as the number of working age man, woman, have an important implication in deciding any particular livelihood strategy. Education increases skills and employment opportunities that lead people to join paid job as traditional livelihood activities are often less rewarding. Forest dependency is a kind of livelihood practice which parents do not want to see their children continue. But chronic poverty brings the family members into the low-income forest resource extraction activities. Numerous initiatives for developing skills of nature-dependent communities have been implemented worldwide to reduce the destruction of the resources.

Age of the household head or young family members is a key feature in deciding livelihood activities. In agrarian families, boys are engaged in farming, raising domestic animals, and collecting firewood. Girls, on the other hand, help in various household activities. Therefore, the number of children in a household ensures a potential supply of child workers which eventually allows elders to increase their income (Admassie, 2003). Young individuals, however, are more likely to leave a low-income occupation and may migrate to other localities outside the community or even country to secure a higher income (Rudel *et al.*, 2002, Jokisch, 2002). Elderly people, on the other hand, generally continue their traditional practices as long as they can. In addition, mental and physical health have also influenced people to take a risk and generate more income instead of sticking with the low-return jobs such as extracting forest resources (Bhandari, 2013).

2.4.2 Physical capital-access

Physical capital refers to the basic infrastructure and the production means and equipment such as schools, houses, roads, hospitals, vehicles etc. which enable the pursuit of various

livelihood strategies in a particular place (DFID, 1999, King, 2011). Adequate access to physical capital is essential for reducing household poverty in both to rural and poor urban households (Osman-Elasha *et al.*, 2006, Briceno-Garmendia *et al.*, 2004).

Geographic proximity of a family to an urban centre is known to influence engagement in non-farm activities. Generally, ecosystem dependent communities live in the remote areas with little or no road network. This is a major obstacle for the development of the active market and as a result, they are discouraged to produce for the purpose of making a profit. However, the presence of good roads and transportation facilities accelerate ecosystem destruction. Large-scale commercially driven logging in Cambodia since the 1970s remained confined to border regions or closer to the major road network. Due to easy access to sea and markets in Thailand and Vietnam, Cambodia forest resources became the key economic assets (Billon, 2002). Takenaka and Pren (2010) argued that physical capitals can deter from their traditional livelihood activities or encourage in doing so. According to the modern economic theory, self-finance asset acquisition (e.g. truck, harvester) is a determining factor of continuing households' traditional livelihood practice (Massey, 1990).

Marginalized households are often poor in physical assets; hence, an asset-based development approach has been adopted by many development agencies. The poor are generally voiceless and asking the communities what they need often fails to reveal what the people actually require to get out of poverty (Deshingkar *et al.*, 2008, Mathie and Cunningham, 2003). Households dependent on ecosystems for their livelihoods are exposed to a wide range of vulnerabilities including water scarcity, death of livestock, climate change and disasters (Hagihara *et al.*, 2016). Physical capital thus plays a vital role in making the families more resilient. The fluctuation in consumption and

degradation of physical capitals caused by the shocks adversely affects household wellbeing and frequently persists even after the shock is over (Dercon, 2004).

2.4.3 Natural capital access

Land ownership is the most influential part of sustaining a livelihood. Landless people are directly dependent on natural ecosystems as these are common-pool resources. Jakobsen *et al.* (2007) showed that the land tenure policy implementation by the Vietnamese government had a snowball effect on the local livelihoods and upland farmers in Thailand. Ownership is vital because it gives more control on other resources such as income generated from land, and socio-political institutions. In Nepal, higher case farmers have more access to the land and thereby dominate the society. In these societies, land is traditionally considered as a source of power which higher caste people are supposed to have. Land ownership not only delivers more economic strength by growing more crops, it also allows them to employ lower caste people to work for them (Bhandari, 2013). Paudel and Thapa (2004) found that lower caste people are engaged with small agricultural activities have not been able to change their livelihoods or adopt new technology in the same way as the upper caste families.

Poverty and reliance on the natural resources in rural areas are intricately linked. In Angola, the Okavango River is a critically important source of livelihoods for people living in the basin. Due to the favourable livelihood conditions, the population of the area continues to grow. Moreover, Namibia and Botswana have also been implementing major development projects based on the river ecosystem (Boyd *et al.*, 2007). Ecotourism sites are predominantly public sites providing benefits even for the landless people. The majority of the revenue from ecotourism is earned by the outside investors; however, employment opportunities for the poor allow them to earn money for subsistence (He *et al.*, 2008). In addition, if an equitable benefit distribution exists, due to high-value

tourism the site gets some extra protection from local people as well as the government. Thus, sustainable conservation goals can be achieved by proper designing natural capital based projects (Campbell, 1999, Johnston, 2014, Bookbinder *et al.*, 1998).

2.4.4 Financial capital-access

Livestock rearing plays a major role in shaping local livelihoods worldwide. Smallholder livestock farming represents about 20% of the world population's occupation. In rural Africa and Asia, farming includes more than one billion poor people predominantly practicing mixed crop-livestock systems. In East and Southern Africa, maize cultivation is closely related to cattle; and in South East Asia, rice is often linked with rearing pigs (Herrero *et al.*, 2012, Jayne *et al.*, 2003). Livestock is potential to generate up to 50% of the family income in the areas where crop-livestock system is the main agriculture practice (Deshingkar *et al.*, 2008). In a pastoral society, livestock is often the only notable financial asset they own (World Bank, 2007). Numerous landless and other poor families indirectly rely on livestock by engaging in activities for supplying feed, transportation services and trading in the market. Despite the growing trend of migration from rural areas to urban areas, many parts of the developing world still hold large livestock population populations and would likely continue to do so in the foreseeable future (McDermott *et al.*, 2010).

2.4.5 Social capital-access

Social capital includes the social resources people build through networks and connectedness, membership of formal and informal groups, and trust relations and reciprocity. Social capital has direct impacts on other capitals for example, by improving the efficiency of economic relations, reducing the free riders problems in common resource management, facilitating networks, innovation, sharing knowledge etc. This

capital is mostly self-reinforcing and easier to increase by capacity building, leadership training or creating an accountable institutional environment (DFID, 1999)

It is common that the poor in need of assistance can generally call on the close friends and family members. Woolcock (2001) found that people who have high-level of social capital may eventually generate mutual benefits. For example, relatives in another town or village can make access to other markets for their products and the urban relatives can get some produce with minimum or no cost. Additionally, relatives in nearby towns can assist in getting government services when necessary. However, these social capitals may not be available to the poorest individuals, who are confined to a very limited livelihood activity and cannot afford to connect with such social networks (Cleaver, 2005). Beall (2001) reported that the dependence on close family relations can produce vulnerability as it is difficult for them to sustain self-help at the same time mutual assistance which can cause conflicts between the families.

A growing number of literatures have demonstrated that local associations play a vital role in successful project implementation. This has been evident in almost all sectors including irrigation and water supply, forest management, and the provision of credit to the poor. The way local associations perform by sharing information among the members, neutralizing opportunistic attitudes, and the facilitation of collective actions (Grootaert, 1999).

2.5 Human Wellbeing

2.5.1 Human wellbeing and Criteria: the poor's perspective

Human wellbeing emerges from the notion that every person in the world, regardless of culture, age, gender, religion deserves to live well. Income is not necessarily a determinant of human wellbeing, instead, it is determined by the individual perception in

terms of material possessions, mental contentment, and relationships that enhance their aptitude in achieving desired goals. Many factors influence an individual's ability to live well including inequality, poverty, malnutrition, political instability, access to resources etc. (Ashton and Jones, 2013). The evaluation of the state of human affairs or designing policies is typically based on the assumptions about the features of a good life. These make the policy makers more sporadic in developing human wellbeing. For example, increasing income of people would enhance the wellbeing is a signature notion of development; hence, increasing economic production per capita is a designated goal. But the underlying assumptions of this approach are rarely tested and established (Costanza *et al.*, 2007).

Human wellbeing generally falls into two categories including objective and subjective wellbeing. Objective indicators are indices of economic production, life expectancy, literacy and other indicators that are quantifiable. These indicators can be represented solely or in combination; for instance, the World Bank's World Development Index (WDI). These objective figures help us gathering standardized data which are predominantly immune to the local and social contexts. However, these assumptions technically compare one's life to other's in a given context and thereby avoid the fact that a person or group has good life simply because others are in more miserable situations (Costanza *et al.*, 2007). Subjective indicators gain impetus from the reality that objective indicators merely focus on the opportunities of the individuals to improve, instead of the measuring the individual wellbeing itself. Economic production may best be explained as one of the means to potentially improve wellbeing. Unlike most objective measures, subjective measures primarily rely on interview tools to collect a respondent's own perception of their wellbeing based on their living conditions. Subjective measures tap into the perceived significance of a particular need to the respondent, presuming the importance the various wellbeing functions such as material possession or life expectancy

(Costanza *et al.*, 2007). Many studies provide enough evidence that subjective wellbeing is a valid indicator of what people perceive to be crucial parts of their happiness (Cummins *et al.*, 2003, Steptoe *et al.*, Dolan and Metcalfe, 2012).

Millions of people who are mostly dependent on ESS are generally poor and marginalized. However, there is an enormous diversity among the people worldwide that is attributed to wellbeing as it is conceptually very multidimensional. This means that one person's version of wellbeing may not match another person's view. However, all the specific needs for a good life generally cluster around five broad heading including basic materials, health, social relation, security, and freedom of choice and action (MEA, 2005, Narayan *et al.*, 2000, OECD, 2013).

The basic materials of sustaining life are food, water, and air. Adequate food is the first priority of the poor. Ecosystem dependence of the people is firstly for food or income to buy food from the market. Fresh air is another important requirement of the local people (Tscharntke *et al.*, 2012). Both perceived and measured air pollution levels significantly affect satisfaction of the people. A small increase in air pollutants corresponds to a significant drop in satisfaction of the residents nearby (MacKerron and Mourato, 2009).

Health, including both physical and mental condition, is always an issue for good life. Access to health and medical services, whether modern or traditional, are important. A healthy and fit body is considered crucial to wellbeing not only for a sense of physical wellbeing per se, it also allows people to work (Kemp and Quintana, 2013). Sanitation is often ignored in the rural areas. In a remote society with a very low level of education especially indigenous community diseases caused by poor sanitation is not even realized (Gracey *et al.*, 1997, Flohr *et al.*, 2006). People living in a society, especially in the rural areas, tend to have a more prevalent sense of social life compared to urban areas. This includes having good social relationships and higher levels of trust and solidarity,

cohesion, personal connection, and membership. These social elements can facilitate mutual benefits and reduce the vulnerabilities of families. Social capital also helps achieve greater equity and effectiveness in government's activities with communities. Equity is advanced through the provision of skills and social connectivity through collaboration with government and others working with communities and thereby, improve access to capitals (Pelling, 1998). An inclusive and fair communities reject discrimination at all levels and strive for tolerance and the peaceful coexistence of the people (Laurence, 2011).

2.5.2 Human wellbeing and ESS

2.5.2.1 Basic needs of life

All the organs of human body contain water which demonstrates the importance of water in keeping us alive. Inadequate access to clean fresh water is a major human health issue worldwide. The paradigm of continued expansion of the water supply infrastructure has been slowed down due to growing concerns about adverse ecological effects of these projects, shortage of financial and social capital, and increasingly strong voices of local and international organizations. Hence, lack of fresh water poses a double threat by affecting health and ecological degradation to the ecosystem dependent communities (Gleick, 1998).

Millions of people in the developing countries suffer from water shortage for almost every day causing harm to the quality of their health and productivity (World Bank, 1993). Individuals must require clean water for drinking, cooking, and washing. It is estimated that dirty water or poor hygiene cause death of 3900 per day; diarrhoeal disease costs 1.8 million lives each year from which is equal to 12 Boeing 747 crash every day (WBCSD, 2006). Collecting clean water is a major part of the rural woman's household work. Often they have to travel a long distance to get safe drinking water. In many areas,

people collect water from a common reserve such as a pond, water-well, stream or river. The water of these sources is not generally clean and exposes people to the risk of various water-borne diseases. Ecosystems including forests, wetlands, and grasslands are the centre of earth's water cycle. All the supply of fresh water ultimately depends on the healthy ecosystems as they operate the biophysical process of producing fresh water. These are particularly important to mitigate the extreme drought and flood.

Changes in land use patterns have been rapidly altering water partitioning since the industrial revolution and have thereby influenced downwind rainfall patterns, runoff generation, and river water flow. Access to both surface and groundwater are linked to the access to the ecosystem that supplies water. With the increasing land and water scarcities and degradation of ecosystems, it is essential to bridge water supply and ecosystem function, and secure integrated management systems (Hundecha and Bárdossy, 2004, DeFries *et al.*, 2004).

2.5.2.2 Food and ecosystem

Food is the most important basic human right and everyone must have the access to nutritious and affordable food for healthy and productive life. Although there has been a great progress in increasing average food intake globally, yet some 795 million people are still suffering from chronic food shortage (FAO *et al.*, 2015). Increased effort to increase food production in the world has major impacts on ecosystems via ecological feedbacks by direct use of resources as inputs, agricultural pollution, changing ecosystem resilience or productivity (FAO *et al.*, 2015, Matson *et al.*, 1997, Tilman *et al.*, 2002).

Forest foods rarely supply the staple or bulk items to a person's diet. In most of the rural families, forest foods add some variety to their diet supplementing proteins, vitamins, and minerals. Leafy vegetables, mushrooms, and wild animals add diversity and flavours, and meet valuable vitamins and mineral requirements of the primarily grain consuming rural

families. Although the wild foods compose a small portion of the household diet, in terms of nutrient supplies those can be a crucial part of the sustaining good health. Wild foods are particularly important in emergency situation such as drought and flood (Byron and Arnold, 1999).

Insufficient food can cause various physical, psychological and social consequences to households. Fatigue, lack of concentration of children, and low working productivity in or out of the home are just a few of these consequences. Lack of food plays a vital role in the managing stress and maintaining self-esteem. A variety of socio-familial perturbations, including disrupted household relations and conflicts in society can be created if the family fails to meet food needs. As a consequence, people reduce participation in social events, transfer of knowledge is hampered and actors of the food supply chain are changed (Hamelin *et al.*, 1999). Food insecurity is one of the important reasons people go to the forests and collect resources. It is demonstrated in many studies ecosystem dependent communities are reluctant to accept any environmental conservation program unless their food security or sufficient income to buy items from the market is ensured.

ESS such as pollination, soil nutrient improvement, and pest control play a vital role in agricultural productivity (Power, 2010). Biodiversity provides important ecosystem services to the farming systems and agricultural landscapes; however, it implicitly neglects the fact that biodiversity and agro-ecosystem can be reciprocally beneficial in short and long terms (Tscharntke *et al.*, 2005, Tscharntke *et al.*, 2012). Only 40% of the terrestrial ecosystem is used for agricultural production and 14% are protected. This demonstrates that some endangered large carnivores such as lynx, wolf, bear etc. cannot be saved from extinction by establishing reserves only, but needs to develop connectivity

with the matrix of semi-natural habitats and protected habitats (Linnell *et al.*, 2005, Weaver *et al.*, 1996).

2.5.2.3 Good social relation and ecosystem

Good social relations in the forest-dependent communities can affect conservation success and vice-versa. A flow of positive impact on social relations can provide incentives for better conservation over the long period. Conservation is certainly a social undertaking and hence, humans are the key stakeholders depending on resources for their livelihoods and wellbeing, and also pose threats to the sustainability of the resources. In recognition to this issue government in developing countries initiated measures such as 'conservation by participatory approach' to improve both human wellbeing and local biodiversity. Conservation policies historically generated conflicts between the management authorities and the local people. These conflicts caused brutal fights, complete eviction of communities and constant social tensions. Recent recognition of the people's rights on the ecosystems led the formation of various local groups and cooperation with different formal and informal institutions. Addressing the problems associated to the management of a socio-ecological system requires collaboration among all the actors (Folke *et al.*, 2002). This will enhance the capacity of a socio-ecological system to adapt with intermittent shocks. The interaction between the actors determines the mode of the behaviour toward each other (Nkhata *et al.*, 2008).

Ecosystems often contain the sites of cultural or spiritual importance. The patches of the dry forest in the Zambezi Valley of northern Zimbabwe are considered sacred places to the local people. Forest loss is surprisingly less in the sacred areas or connected to sacred forests. The traditional spiritual values influenced the people to change behaviour affecting the forest and have played a vital role in conservation (Byers *et al.*, 2001). Cultural services, such as traditional ecological knowledge, and cultural identity assist

social cohesion (Berkes, 2012). Pastoralists get cultural identity due to their dependence on the landscapes they live in. Transhumance is a traditional practice of mobile pastoralism that is associated with the regular seasonal migrations of livestock herds between high lands in summer and lowlands in winter. This cultural practice maintains a unique cultural landscape in Mediterranean Spain which has been shaping the pastoral societies over centuries. In order to maintain the wellbeing of the society, people work hand-in-hand (Cousins, 1996, Gifford-Gonzalez, 1998). These social structures have generated much indigenous knowledge to maintain their livelihoods (Berkes, 2012).

2.5.2.4 Security and ecosystem

Several studies show many rural people use a wide variety of forest resources and heavily dependent on wild resources for their livelihoods (Babulo *et al.*, 2008, Dewi *et al.*, 2005, Ameha *et al.*, 2014, Kalaba *et al.*, 2013). The poor quality of natural resources and unequal access to the natural ecosystem by the local people can undermine human security damaging local livelihoods and fuel national conflicts (Barnett and Adger, 2007). Resources scarcity in a forest-dependent community can hamper personal security of the wealth and properties of local people. Losses due to the insecurity eventually exert further pressure on the people for more resource collection. People depend on the forest or other ecosystems in various ways. However, unsustainable extraction of the resources led resource scarcity. When the resources were abundant and the dependent communities were small then they could meet their all their family demands by the resources obtained from the ecosystems. But due to the growing population the ecosystems are not able to produce enough to support the communities. In many parts of the world, nature only supplement to the family income and consumption. This uncertainty of the resources exerts mental pressure on the collectors. In order to meet the family demand more members get involved in resource extraction e.g. children join the collector to assist.

Increased availability of ESS provide greater economic security to the local people. Easy availability also provides opportunities for additional economic engagement and thereby enhances livelihood security. Kaewmahanin *et al.* (2008) found that increased mud crab harvesting resulted in innovative introduction of crab banks, artificial fish houses have been installed in canals. Villagers and outsiders need less time for fish harvesting. This economic security convinced people to engage in the coastal conservation activities. A certainty of livelihood activities is essential for a secured life. An ecosystem generates a variety of services which may lead to conflicts of interests among different groups or organizations. For example, timber companies have vested interests in the profits derived from timber of a forest. Governments earn revenues and foreign exchange from the taxes and fees paid by the companies (Ndoye and Tieguhong, 2004). Conflicts and competitions exist between the local people appointed by the companies and those who are not employed by the companies. A high value of the resources may also invite external agencies or groups to benefit from the resources and jeopardise social harmony (de Groot, 2006).

The rural poor are marginalized and have less access to the financial resources. They require engaging in economic activities with higher risks because they are vulnerable to any financial shock. Available and affordable sources for emergency loans play a vital role in taking those risks. Human capital development plays a major role in reducing poverty and improve environmental management (Bils and Klenow, 2000, Daw *et al.*, 2011). It is highlighted that lack of infrastructure and resources cause limited education in developing countries. These communities are mostly dependent on the ecosystem because of the budget constraint for other activities such as schooling children. Young children often are engaged in income generating activities to increase family income. Low schooling rate reflects the effects on the demand for education by the families and competing demands for labour in ESS extraction (Maldonado and González-Vega, 2008).

Financial resources allow households to engage in productive opportunities and enhance the capacity for coping with the risks. Inadequate credit hinders the growth of small business by limiting the expansion by the loans but not the market size (Kuzilwa, 2005).

2.5.2.5 Freedom of choice and ecosystem

Constraints to access to any capitals leave the poor with less diversified assets and income leading them to bear both lower returns and higher variability in income. The poor have trouble in breaking out of the diverse range of low return activities force people to enter un-remunerative activities where entry and exit is reasonably risk free. But the wealthy section of the society can drive for more lucrative ones (Barrett *et al.*, 2005, McPeak and Barrett, 2001). Wealthier people can generate some employment for the poor people but there has been a tendency to hire from outside as local people lack necessary skills. Ecosystem dependent communities are generally dependent on the ESS and any constraints in reaching the services jeopardize their wellbeing (Dewi *et al.*, 2005). Lack of freedom in using the limited capitals gradually diminishes their abilities to sustain livelihoods. In the marginalized society social freedom is an important force to continue their livelihood activities as they have lower financial, physical and human resources (Farrington and Farrington, 2005).

Those who are poor, are also powerless in the society. A just society grants the opportunity for participation in activities to its all members (Farrington and Farrington, 2005). The most important activity of the ecosystem dependent people is to collect ESS. There is always competition for the resources from an ecosystem, especially where the population is higher than the productivity of the ecosystems. Competition may create conflicts and generate disrespect with each other. Injustice excludes poorer people from getting access to the services and thereby limits the freedom for conducting the livelihood activities (Farrington and Farrington, 2005, Dewi *et al.*, 2005). In the rural areas, formal

justice system is often absent. Generally, the village headman or commune head along with some other influential people in the society maintain the law and order in the society. Large scale conflicts are mainly managed by the formal judicial systems of the country. An active social judicial system is essential especially for the poor to exercise their rights freely.

In a marginalized society, the organizational process that leads to social justice primarily depend on the existing socio-economic and power relations among the members (Barraclough and Ghimire, 1995). Within the social structure, no system is autonomous and always constrained by various forces (Thomas and Twyman, 2005). If any household fail to position themselves within the power structure, gradually they become further marginalized (Timsina, 2003).

Freedom of choice is directly or indirectly influenced by the other wellbeing criteria. The wealthy citizens who have good governance and active civil society can maintain the freedom of choice and action even in the face of major ecosystem change but the subsistence poor are the easy victim of any change in the ecosystem as they lose their livelihoods (Boon, 2013, Barraclough and Ghimire, 1995).

2.5.3 Human wellbeing and sustainability

Sustainable development is the central concern of the latest development worldwide. The features of human wellbeing and sustainability vary across the world and disciplines (Hopwood *et al.*, 2005). The World Commission on Environment and Development defined sustainability as the using inter-temporal resource based on an ethical theory of inter-generational equity i.e. the present generating required to use the resources in a fashion that leave enough of these for the future generations to maintain a good level of wellbeing. Human wellbeing relies on both manmade capital and natural environment. The support of natural assets is no longer being considered abundant in both

quantitatively and qualitatively because of the unprecedented demands of human society. The quality of the life of the people primarily depends on how the available assets are managed (Sengupta, 2002).

Ecological or social or political sustainability refers to the structure and composition of the respective system and the institutions govern them. In such contexts, there are always contradictions between economists and ecologists (Pearce and Warford, 1993). Economists have always been intended to value everything which scarce and generate a cardinal and ordinal index to solve problems by making trade-offs. In the context of economic development, sustainability has therefore focused on monotonic non-declining nature over time, and thereby insists that the level of all kinds of stocks or institutions will remain unchanged by resource substitutions, which ecologists treated as the continuous pressure on the resources and thereby suggest to use by taking the production capacity of a system (Giddings *et al.*, 2002, Sengupta, 2002).

Sustainability is not a matter of simply ensuring some aggregate level of human and natural capital, it requires maintaining the flow of specific goods and services to meet diverse human needs and capacities. Construction of a weir in Yoshino river in Japan was stopped after a referendum in which people in the downstream participated only. Therefore, sustainability of a particular group was attained but up- and midstream communities who needed the weir to protect from the flood was not secured (Hagihara and Asahi, 2016). Environmental sustainability is defined as meeting human demands without undermining the capacity of the environment to generate goods and services to support the life on earth over the long term. However, this concept is often difficult to operationalize in reality primarily because of the absence of national and international targets. In order to reverse current ecosystem destruction rate, it is essential to consider

the national and regional targets, and strengthening capacities at regional, national and local level.

Operationalizing environmental sustainability is very complex. Variability of ecosystems and their functions over the course of time and space create a major challenge. Moreover, social and environmental outcomes imply many difficult trade-offs. For example, establishing a protected area often creates conflicts with the local people who are dependent for their livelihood. Reconciling the competing demands on scare ecosystem resources is a never-ending challenge and arbitrating the interests of present and future generations make the achievement of sustainability is a no-easy-task. On the contrary, environmental degradation is inextricably and causally linked to the major development problems including poverty, food insecurity, and inequality. A healthy and functional natural environment provides necessary supports to overcome the aforementioned development issues. Traditional environmental concerns are set as the low priority and give a setback in considering the environmental issues as a trade-offs component with the major economic issues such as transport and energy.

For too many people, environmental degradation obscures the hopes of surviving with the very basic human needs. In developing countries one in five persons lacks access to safe drinking water, one billion people live in degraded lands, and 1.2 billion people live less than $1 a day. They all are either directly or indirectly the victims of degraded natural ecosystems (Melnick, 2005). Consumption patterns of the rich force overexploitation of natural resources, but the poor lack the resources they required to survive the daily struggle. Their inadequate property rights, fragile resources supply, and limited access to the credit prevent them to invest or participate in sustainable ecosystem management. In addition, with few alternative income sources, they extensively rely on the ESS such as land, food, fuel, water etc.. When the ecosystems are degraded the poor become poorer;

therefore, environmental degradation and resource depletion substantially lower national savings rates.

Ecosystem sustainability is not only is an issue for the poor, the greatest threats to ecosystem sustainability derive from the actions taken in the developed countries. Therefore, fundamental changes in the way humans produce and consume are indispensable in order to achieve global sustainability and the developed countries must take the leading role in this regard. Deforestation is only partly caused by the local demands. The demands from the industrialized nations are the major driver of the destruction. Similarly, the scale and intensity fisheries, minerals energy and other biological resources exploitation are predominantly determined by the demands from the richest nations. Enhancing human wellbeing and achieving sustainability requires charting a new path for development between the extreme resource degradation, and unsustainable consumption and production. To do so requires setting up a clear and ambitious set of strategies, and creative and visionary leadership in each nation.

2.5.4 Trade-offs for ecosystem conservation and human wellbeing

In our world of persistent poverty, an increasing demand for resource extraction, and environmental changes are becoming seemingly insurmountable challenges in conserving the earth ecosystems. Despite the wider understanding on the loss of biodiversity it is yet to be determined how to respond to the loss effectively. Over the last few decades, ecosystem management has been shifting to the local community development. However, the initiatives were primarily focused on the economic and social development by involving the state institutions in collaboration with the local communities. These collaborative approaches have shown a sporadic success. To address the issue MEA (2005), has referred the human development by managing ecosystem as 'Human wellbeing' with a more inclusive and robust definition of wellbeing. But most of the

ecosystems in the world are under enormous pressure from both local and international consumers. It is unreasonable to stop people from enjoying ESS simply for the sake of conservation, and giving people all the power to manage the resources is not a viable option either (Songorwa, 1999, Baynes *et al.*, 2015, Leach *et al.*, 1999). Hence, a trade-off is required between conservation and human wellbeing (McShane *et al.*, 2011).

Many ecologists criticize the notion of reliance on the extraction and use of ESS as being fundamentally and ecologically unsound, encouraging overexploitation, and failing the stakeholders who may play a vital role in ecosystem protection (Robinson, 1993, Scholte and De Groot, 2010, Songorwa, 1999). On the other hand, efforts to establish links between economic incentives and local development to conservation initiatives are also criticized for not being efficient enough in generating sufficient economic returns, failing to ensure fair benefit distribution to the disadvantaged groups, and creating conflict with the existing livelihood practices (Wells and McShane, 2004).

The essence of trade-offs encompasses the idea that gaining something is essentially losing something as well (Kibria *et al.*, 2015). Acknowledging the trade-offs implies appreciating not only the gains but also accepting the losses happened due to the choices and actions of different stakeholders. Thus, trade-offs bring diverse actors to a common ground which is hard to achieve in reality. Each option of choice has its own set of possible outcomes with respect to human wellbeing and ecosystem conservation. In many cases, choices are decided without even knowing what to be sacrificed because of the lack of knowledge and multidisciplinary decision-making team. Proper trade-offs will result in more well-designed, resilient and sustainable initiatives (McShane *et al.*, 2011). While acknowledging the conservation and human wellbeing achievements is difficult, there is still little understanding of wellbeing both in theory and practice in the complex set of social and ecological aspects (Brechin *et al.*, 2003). Understanding the values of

ESS, local people's access to ESS and the overall effect of ESS on the wellbeing of the dependent communities would greatly assist in making trade-offs between development and sustainable conservation.

Chapter 3

The value of Ecosystem Services Obtained from a Conservation Forest in Cambodia: The Case of Veun Sai-Siem Pang National Park

Abstract

This research provides for the first time a valuation of Veun Sai-Siem Pang National Park (VSSPNP) in Cambodia, which is a forest largely unfamiliar to the international community yet extremely significant in terms of biodiversity value. This study aimed to measure the monetary and non-monetary values of ecosystem services (ESS) of the forest. I estimated the total annual contribution of VSSPNP to be US$129.84million. Its primary contribution was air purification (US$56.21million yr^{-1}) followed by water storage (US$32.31million yr^{-1}), soil-erosion reduction (US$22.21million yr^{-1}), soil-fertility improvement (US$9.47million yr^{-1}), carbon sequestration (US$7.87million yr^{-1}), provisioning services (US$1.76million yr^{-1}) and recreation (US$0.02million yr^{-1}). Traditionally the forest is used for timber and non-timber forest products (NTFPs), which in fact, composed only 1.36% of the total benefits. By analysing published articles and reports on VSSPNP I determined the area had generated valuable academic and non-academic knowledge on natural resources. This forest had also created a diverse network among scientists and different organizations worldwide. I also identified the forest to be of cultural importance for indigenous people as they believe that their ancestors live inside the forest and protect them from vulnerabilities. Despite being part of one of the most important eco-regions in the world VSSPNP is undervalued and facing multiple threats such as illegal logging, poaching, population pressure and corruption. The current estimation of ESS would thus assist to sustainable management of VSSPNP.

3.1 Introduction

Forest ecosystems are capital assets that yield many vital services for humans (Costanza *et al.*, 2011). Their importance, however, is often determined by comparing their value with that which could be obtained from converting forests for other land uses (i.e. agriculture) (Costanza *et al.*, 1997). The ecosystem services (ESS) of forests identified by previous researchers are food, water, fuel, timber, fibre, climate regulation, flood regulation, disease regulation, water purification, and spiritual and recreational considerations (MEA, 2003, Fisher *et al.*, 2014). These are broadly categorised in four groups- provisioning, regulating, cultural and supporting services.

Despite large potential ecosystem values, the increasing conversion of native ecosystems into agricultural land, to meet ever-increasing food demands worldwide, is a major cause of habitat destruction, which has resulted in the loss of valuable ecosystems (Sunderlin *et al.*, 2005, Tilman *et al.*, 2001). Land for agricultural expansion comes from a forest, grassland, and other natural ecosystems. If current global trends continue, the net loss of natural ecosystems to agriculture would amount to 10^9ha by 2050 –larger than the total area of the USA (Tilman *et al.*, 2001). Tropical forests, by nearly all means, account for the richest biodiversity found anywhere in the world, yet, ironically, these forests are also among the most threatened (Valiela *et al.*, 2001). Tropical forests are more than just a combination of flora and fauna; they are home to many indigenous people, and are vital source of numerous services such as flood amelioration, soil erosion control, fresh water supply, air purification, recreation, education etc. (Laurance, 1999, Costanza *et al.*, 2014). The most prominent impact of tropical forest destruction is the loss of these precious ESS (Costanza *et al.*, 1997, Daily *et al.*, 2009, de Groot *et al.*, 2012). This issue, however, has been largely ignored in forest and environmental policies, and conventional economic justifications have often underestimated the true contributions of forests. This has often

led to the conversion of forests to agricultural land uses, as well as to lower investment in forest conservation (Daily *et al.*, 2009, Costanza *et al.*, 1997).

Forest ecosystems are great sources of knowledge and destinations for diverse research efforts. Scientific articles, reports, popular articles, and visits to the forest ecosystem communicate with the wider society and grow interest and awareness on ecological relationships (Costanza *et al.*, 1997). Every year countless meetings, conferences, workshops and symposia are organized worldwide to share knowledge and determine priorities in social, economic and environmental policies. Climate change due to carbon emission, rapid biodiversity loss, local and national dependence, conversion into commercial plantation and numerous management challenges (Boon, 2013, Laurance, 1999, Bawa, 2006) make forests more powerful than ever before to make connections and start dialogue among researchers and public and private owners (Andersson *et al.*, 2000).

Given the importance of ecosystem services to sustainable human development, it is time for some important questions to be addressed: How important are the ESS? And At what scale? The answers to these questions are not entirely academic. We make choices among the competing options by comparing 'benefit to be gained' from them which implies 'valuation' (Section 2.2). In most cases environmental benefits are not properly evaluated and, thus, tend to be underestimated in the cost-benefit analysis of any proposed action (Costanza, 2000). Valuation of all the possible ESS would not only increase the economic value of the ecosystem, it also will highlight the socio-cultural services of natural ecosystems (Daniel *et al.*, 2012, Barrena *et al.*, 2014). Communities have their own considerations in valuing the ecosystems and often the socio-cultural values are not adequately incorporated in decision making (van Riper *et al.*, 2012). Monetary and non-monetary values can complement each other and generate greater ecosystem services by facilitating communications between stakeholders and enabling comprehensive

evaluation that frames all the aspects of ecosystem's contribution within the broader ESS framework (Daniel *et al.*, 2012, deGroot *et al.*, 2010). The decline of any type of ecosystem services in and outside the sources of services often create conflicts within communities (Zarandian *et al.*, 2016).

Decision makers require better information on the comprehensive values of nature for weighing human actions on the ecosystem (Bingham *et al.*, 1995). Millions of people in developing countries live adjacent to forests and their wellbeing is closely linked with forest resources (Smith *et al.*, 2013). Moreover, many services are of benefit to humans at national and regional levels, which suggests that forest destruction would cause irretrievable damage to general human wellbeing (Daily *et al.*, 2009). Unless we drastically improve our understanding of the values offered by ecosystems in conservation efforts, we cannot hope to improve forest conservation and thus the sustainability of human wellbeing cannot be ensured (Smith *et al.*, 2013).

Cambodia has one of the highest rates of land-use change globally (Davis *et al.*, 2015, Hansen *et al.*, 2013). The country is of global conservation importance because it contains the largest remaining examples of habitats that were previously spread across much of Indochina and Thailand, and which still contain nearly intact species assemblages, albeit at heavily reduced densities (Loucks *et al.*, 2009). Veun Sai-Siem Pang National Park (VSSPNP) in North-eastern Cambodia has been listed as a Key Biodiversity Area in the World Biodiversity Database and is also part of the Virachey Important Bird Area (Chan *et al.*, 2004). VSSPNP contains significant populations of rare and endangered species (e.g. the red-shanked douc langur and the giant ibis) and is home to several indigenous hill tribes and other people including Brao, Lao, Kavet and Kinh. Due to chronic poverty, illegal logging and poaching activities are threatening the site's ecological integrity which when paired with other human-induced ecosystem changes and

general impacts of climate change, may result in catastrophic consequences (POH-KAO, 2012). On May 09, 2016, VSSPNP is declared as protected area to provide better means to conserve the richness of the forest. Conservation International has been implementing conservation projects in the forest, but in the absence of an estimation of ESS provided by the area to justify greater investment and attention provided towards its protection, this has been challenging. To address this research gap and examine whether benefits will accrue if this area is upgraded from a conservation area to a protected area, my study aimed to estimate ESS values derived from VSSPNP.

3.2 Methodology

3.2.1 Study site

VSSPNP is located in 14°01' N, 106° 44' E and consists of approximately 55638.72ha of evergreen (54486.81ha) and semi-evergreen (1151.91ha) forest (Figure 3.1). This area experience two distinct seasons: the wet season occurs from May through October and the dry season from November to April. It has a mean annual temperature of 28°C (ranges from 38°C in April to 17°C in January) while the mean annual precipitation ranges from 1,200–2,000mm and is governed by monsoons (Thoeun, 2015). Topographically the area is mixed with hilly and plain lands with red sandy soil. VSSPNP is a large pristine forest in North-eastern part of Cambodia contiguous with Virachey National Park which is just above it and borders Vietnam. The forest is characterized by patches of mixed deciduous and semi-evergreen forests (Chan *et al.*, 2004). The VSSPNP area is located in the Veun Sai District of Ratanakiri Province and Siem Pang District of Stung Treng Province. There are 474 indigenous families living in the surrounding villages of VSSPNP. Ecologically, the area is located within the Indo-Burma hotspot (Myers *et al.*, 2000), and is part of the 200 globally most important

ecoregions, the Eastern Indo-China Dry and Monsoon Forest (Olson and Dinerstein, 1998) and part of the Critical Ecosystem Partnership Fund's (CEPF) Cambodia-Lao PDR-Vietnam Tri-border Forests priority corridor (Critical Ecosystem Partnership Fund, 2012).

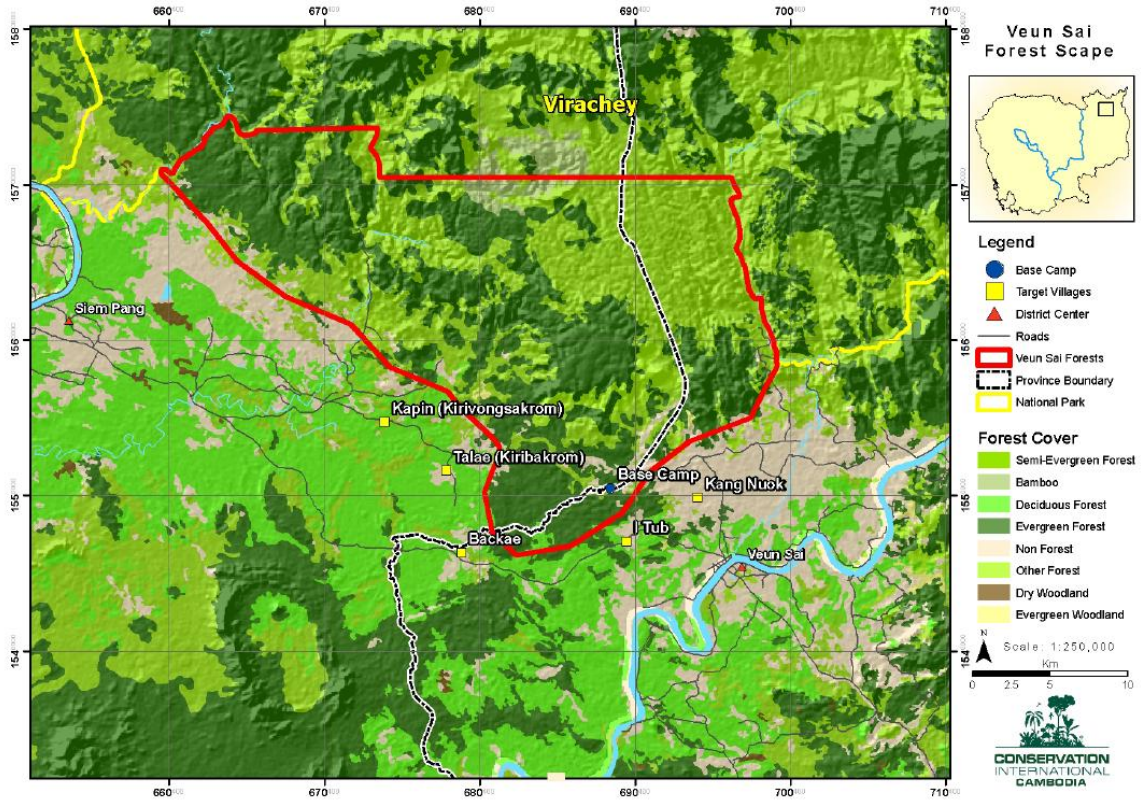


Figure 3.1: The Veun Sai-Siem Pang Conservation Forest (inside the red boundary); source: Ramachandra *et al.* (2012).

In VSSPNP 255 animal species have been recorded of which four are classified as Critically Endangered, 12 as Endangered, and 19 as Vulnerable on the IUCN Red List of Threatened Species (Ramachandra *et al.*, 2012). Primates of this area are of special conservation concern. The population of gibbons at the site is considered globally significant (Rawson and Bach, 2011) as it is believed to be the biggest population of the species *Nomascus annamensis* in existence. Other species of concern include Black-legged douc langur (*Pygathrix nemaeus*), Dhole (*Cuon alpinus*), Malayan sun bear

(*Helarctos malayanus*), gaur (*Bos gaurus*), banteng (*Bos javanicus*), Eastern Eld's deer (*Panolia siamensis*), and two species of Slow Loris (genus *Nycticebus*). The site is also home to rare birds such as: white-winged duck (*Cairina scutulata*), giant ibis (*Thaumatibis gigantean*) and white-shouldered ibis (*Pseudibis davisoni*) (Ramachandra *et al.*, 2012).

3.2.2 Valuation of ESS

I considered food, water, NTFPS and timber as provisioning services; water purification and soil erosion reduction as regulating services; recreation, education, traditional ethno-cultural belief as cultural services; and nutrient improvement as a supporting service (Maynard *et al.*, 2015, Fisher *et al.*, 2014, MEA, 2003). These ESS were chosen for this study as they were flagged by local people and NGO officials as being of particular importance. In this research I used simplified methods to measure the value of major ESS of VSSPNP which is easily understandable and can be used by a person with little technical knowledge. The data regarding household income from provisioning services have been double checked by the village headman, local villagers and NGO officials to make those more precise.

3.2.2.1 Provisioning services

Rural people in the villages adjacent to VSSPNP collect timber, resin, malva nut, bamboo, mushroom, and wild animals from the forest. Data regarding income from provisioning services were collected by interviewing 35 indigenous households selected at random. Quantitative and qualitative data were collected from key informant interviews and group discussions with the local indigenous people, research assistants and village elders (POH-KAO, 2012, Persson *et al.*, 2010, Ramachandra *et al.*, 2012) and then supplemented with information from published sources. Direct market valuation

methods were used to calculate the value of these services of the forest (Hein *et al.*, 2006, Costanza *et al.*, 2011).

3.2.2.2 Carbon sequestration

As carbon sequestration varies with many factors (e.g. type of forest, climatic conditions, geographical location, disturbance level etc.), studies for a long period of time can produce precise estimation of annual rate of carbon sequestration. At present there are few carbon flux measurements in tropical forests over a period long enough (5yr or more) to generate a precise annual estimation of carbon sequestration.. The average net carbon sequestration rate in selectively logged evergreen rain forest and in semi-evergreen forest is used (Malhi *et al.*, 1999, Xi, 2009, Cao *et al.*, 2006, IPCC, 2000). In some countries, carbon tax has been introduced for pricing the carbon emitted from various industrial process (e.g. fossil fuel burning). Hence, carbon tax is used to determine the price of carbon emission (Creedy and Wurzbacher, 2001, Huang and Kronrad, 2001). For this study carbon tax of South Korea (US$54/tC) is used as it is situated in Asia and the only country introduced the carbon tax in this region (World Bank, 2016) (Table 3.1). The carbon sequestration value of VSSPNP is calculated by using the following formula (Xi, 2009, Ninan and Inoue, 2013, Creedy and Wurzbacher, 2001):

$$V_c = Q \cdot P \cdot S$$

Where, V_c = Service value of carbon sequestration (US$), Q = Net carbon sequestration rate (t $ha^{-1}yr^{-1}$), P = International carbon price (US$/tC), S = Area of forest (ha).

3.2.2.3 Water storage

A forest ecosystem is often referred to as a "sponge" and "green reservoir" for its immense osmosis-effect and watershed protection capacity. By regulating runoffs, forests can contribute to delay in flood peaks and reducing flood volumes; in dry seasons, forests gradually release absorbed water that maintains river flow and relieves droughts. Subtracting evaporation from the total rainfall overestimates the water storage capacity of the forest, because part of the rainfall is used by plants or stored in soil (Capillary and Hygroscopic water). Therefore the ratio of rainfall and runoff must be considered to overcome this problem (Xie *et al.*, 2010) (Table 3.1). The runoff coefficient method is one of the most simple and widely used methods to measure the runoff yield of the catchment (Negassi *et al.*, 2002). One commonly adopted valuation method is the rainfall storage method is be used for this valuation (Biao *et al.*, 2010, Xi, 2009). The equation is:

$$V_w = Q \cdot C_{rc} = S \cdot J \cdot R \cdot C_{rc} \text{ [here, } J = K \cdot J_0 \text{ and } R = (R_0 - R_g)\text{]}$$

Where, V_w = Annual economic value of forest ecosystems in watershed protection (US$); Q = Increase in water preserved per year in forest ecosystems, compared to bare land (or non-forested area) (m^3); C_{rc} = Cost of reservoir construction per m^3; S = Area of the forest (ha); J = Annual average precipitation runoff yield of the study area (mm); R = Benefit coefficient of reduced runoff in forests compared to bare land (or non-forested area) (%); J_o = Annual average precipitation of the study area (mm): K = Ratio of precipitation runoff yield to total precipitation of the study area; R_0 = Precipitation runoff rate under precipitation runoff condition in bare land (or non-forested area) (%); R_g= Precipitation runoff rate under precipitation runoff condition in forests (%).

In this study, the ratio of precipitation runoff yield in relation to total precipitation of the project area. The reference of R parameters was selected for subtropical evergreen broadleaf forest, and subtropical evergreen deciduous forest categories (Xi, 2009) (Table 3.1).

3.2.2.4 Soil erosion prevention

As a protection layer of the ground, forests help to prevent soil erosion and minimize sedimentation in reservoirs and rivers, thus extending reservoir life. The function of forests in rainwater retention and reduction of rainfall volume and velocity reaching the ground serves to regulate runoff quantity and speed soil loss. One method of estimating the value of reduction in soil loss is equivalent to the cost of sediment removal from rivers and reservoirs. In this study, the soil erosion in non-forest area and the erosion of broadleaf forest (Xi, 2009), and cost of per ton of sediment removal are used (PPWS, 2015) (Table 3.1). The formula for calculating the value of soil erosion prevention by forests is as follows (Xi, 2009, Ninan and Inoue, 2013):

$$V = C_{sr} \cdot G \sum S_i \cdot D \ \ [\text{here}, D = (d_i - d_0)]$$

Where, V_{sc}= Economic value of soil conservation (US$); C_{sr}= Cost of 1 ton of sediment removal (US$); S_i= Area of the respective type of forest (ha); D= Erosion reduction in forest land (t ha^{-1}); G=Ratio of amount of sediments entering rivers or reservoirs to total soil lost; d_i= Rate of erosion of broad leaved forest (t ha^{-1}); d_0= Rate of erosion of non-forest land (t ha^{-1}).

Table 3.1: Data used in measuring the values of ESS of VSSPNP.

ESS	Secondary data used	Value	Source	Assumption
Carbon sequestration	i) Area of evergreen forest	54486.81ha	(Ramachandra *et al.*, 2012)	The forest is contributing the CO_2 removal from the atmosphere and thereby reducing the effect of global warming.
	ii) Area of semi-evergreen forest	1151.91ha		
	iii) Total area	55638.72ha		
	iv) Net carbon sequestration in logged evergreen rain forest	2.65tC $ha^{-1}yr^{-1}$	(IPCC, 2000)	
	v) Net carbon sequestration of logged semi evergreen forest	1.1 $tCha^{-1}yr^{-1}$		
	vi) Carbon price	US$54/tC	World Bank *et al.* (2016)	
Water storage	i) Ratio of precipitation runoff yield	0.60	Xi (2009)	The forest saves development costs of water storage.
	ii) Benefit coefficients of reduced runoff in forests	0.39; 0.34		
	iii) Annual perception of Veun Sai	2405mm	Someth *et al.* (2010)	
	iv) Cost of reservoir construction	US0.12m^{-3}$	Xi (2009)	
Soil erosion prevention	i) Sediment removal cost	US2.5t^{-1}$	PPWS (2015)	The forest saves development cost of sediment removal from the watershed.
	ii) Rate of erosion of broad leaved forest	0.5t $ha^{-1}yr^{-1}$	Xi (2009)	
	iii) Rate of erosion of non-forest land	319.8t $ha^{-1}yr^{-1}$		
Soil fertility improvement	i) Total N in forest soil	1.31g kg^{-1}	Cao *et al.* (2006), Xi (2009)	The forest saves the extra investment required to apply fertilizers to produce food and NTFP for the dependent communities.
	ii) Total P in forest soil	0.26g kg^{-1}		
	iii) Total K in forest soil	7.33g kg^{-1}		
	iv) Price of N-fertilizer	US0.20kg^{-1}$	(World Bank, 2016)	
	v) Price of P-fertilizer	US0.07kg^{-1}$		
	vi) Price of K-fertilizer	US0.20kg^{-1}$		

3.2.2.5 Soil fertility improvement

The forest also helps to maintain fertility since soil erosion may result in losses of N, P, K and organic substance which can be regarded as proxy for nutrient cycling function. As fertilizers do not have a market value, the value of nutrients (N,P,K) are measured by comparing them with the market price of artificially produced nutrients. Therefore, the fertility improvement is compared with the cost of artificial application of nutrients to the

same level. Thus, the nutrient cycling valuing formula is as follows (Xi, 2009, Ninan and Inoue, 2013):

$$V_f = D \cdot S_i \sum P_{1i} \cdot P_{2i} \cdot P_{3i}$$

Where, D= Erosion reduction in forest land compared to non-forest land (t ha^{-1}); S_i= Area of the respective type of forest (ha); P_{1i}= Content of N, P, K in forest soil (%); P_{2i}= Ratio of pure N, P, K to their fertility counterparts. The ratio of N, P, K to their fertilizer counterparts are 60/28,406/62,74.5/39 respectively (common fertilizers used are urea for N, Calcium Superphosphate for P and Potassium Chloride for K); P_{3i}= Price of fertilizers (i.e. Price of urea, Calcium Superphosphate and Potassium Chloride in US$).

Due to lack of sufficient data for VSSPNP, the soil nutrient data of the Xishuangbanna monsoon forests of Yunnan, southernmost China, were used. This area is ecologically indifferent to my study site as it is also included in the Indo-Burma biodiversity hotspot and experience tropical climate (Table 3.1).

3.2.2.6 Air purification

The particulates and air polluting gases move around the world. Although some studies have tried to find out how far air pollutants travel, there is no study was able to successfully identify the sources of particulates and gases in the atmosphere, i.e. a gas particle emitted in a country can travel to other countries (Lu and Turco, 1995, Asimakopoulos *et al.*, 1992). Forest purification includes the following functions: i) Absorption of harmful gases such as SO2, NOx, HF; ii) reduction of particulates of the air. The method commonly adopted involves area absorption (Xi, 2009). The formula is:

$$V_{aq} = \sum_{i=1}^{n} S \cdot Q_i \cdot C_i$$

Where, V_{aq} = Value of air quality improvement (US$), S= Area of the forest (ha); Q_i= Absorption or adsorption of the i^{th} pollutant per unit area ($kg^{-1}ha^{-1}$); C_i= Treatment cost of the i^{th} pollutant (US$/kg); V_e= Value of air purification by forest (US$ yr^{-1}).

For this formula data regarding absorption capacity of broad leaved forest has been used. The treatment cost of the pollutants China is used for this study (Xi, 2009) (Table 3.1).

3.2.2.7 Recreational value

In this study, gibbons are considered as a recreational service for which an ecotourism program was implemented in 2012. Firstly, I calculated each year's revenue generated by VSSPNP and then the average annual value of the forest was calculated (Baral *et al.*, 2008, Adams and Infield, 2003). Hence, recreational value per year was measured by the following formula:

$$V_r = \sum_{i=1}^{n} V_{r_i} = \sum_{i=1}^{n} N_i \cdot P_i$$

Where, V_r = Total recreational value of the forest (US$); V_{ri} = Recreational value of i^{th} year; N_i= Number of tourist in i^{th} year; P_i = Average price of the tour package paid by the tourist in i^{th} year.

3.2.2.8 Educational and scientific value

It is recognised worldwide that forests are great sources of knowledge (Xie *et al.*, 2010, Maynard *et al.*, 2015, Costanza *et al.*, 1997, MEA, 2003). VSSPNP received great

attention from local and international scientists. I explored scientific and educational values of the forests by examining: a) How many schools/institutes visited the area as study tours, b) How many people from different countries visited the site, c) How many researchers were involved, d) How many theses (MSc, PhD) were produced based on data from the site, e) How many articles and reports have been published on VSSPNP and what contributions have been made to the existing knowledge of natural resource management from such studies (deGroot *et al.*, 2010).

3.3 Results

3.3.1 Monetized value

While the benefits of the ESS of VSSPNP may reach villages far from the actual forest (i.e. air purification and soil fertility carry on to many villages outside immediate proximity), the three villages used in this study were located within 1-7km from the study site. It was found that indigenous people harvested 12 different goods from the forest. All the villagers were involved in collecting firewood as it was the only source of household cooking energy. VSSPNP was a great source of different food items and crops. Almost all the households were engaged in extracting two of the most important food items, including 'mushroom' (98%) and 'rattan shoot' (92%). The total market value of these two items collected by the villagers were US\$2230yr^{-1} (mushroom) and US\$4579yr^{-1} (rattan shoot). The majority of the families were also engaged in collecting malva nut (80%) as cash crops, which were worth US\$14220yr^{-1}. Some families (20%) extracted resin from *Dipterocarpus spp.* which was considered a vital source of household income. Timber harvesting for income and house-building was performed by 96% villagers at an average of 6.37m^3yr^{-1} which was valued as US\$3503yr^{-1}. Several families reported that they used to earn about US\$5000yr^{-1} just from a single luxury timber tree, Rosewood,

however due to overexploitation, the rosewood is no longer available; hence, they have shifted to other less valuable trees. Watersheds (river and streams) in the forest area were found to be vital sources of various fish for the villagers (90%), which were worth US$53325yr^{-1}. People also hunted for different wild animals for consumption and sometimes to sell for profit at the local market. Thus, in total, the value of the provisioning services supplied by VSSPNP was calculated to be US$1.76million yr^{-1} where each household earned US$3720yr^{-1} (Table 3.2).

Table 3.2: Major provisioning services harvested from the forest and their values.

Services	Collected amount (unit yr^{-1})	Household income (US$ yr^{-1})	% households collected	Total value (US$ yr^{-1})
Timber (m^3)	6.37	3503	96	1594233
Mushroom (kg)	12	4.8	98	2230
Rattan shoot (kg)	30	10.5	92	4579
Bamboo shoot (kg)	65	65	100	30810
Fish (kg)	50	125	90	53325
Resin (kg)	75	60	20	5688
Jungle fowl (kg)	3	12	5	284
Lizard (kg)	10	25	50	5925
Frog (kg)	20	52	10	2465
Snake (kg)	7	175	5	4148
Malva nut (kg)	15	37.5	80	14220
Fire wood (kg)	60	96	100	45504
Total				1763410

I found that the conservation forest of VSSPNP sequestrates carbon worth US$7.87million yr^{-1} at a rate of US$141ha^{-1}yr^{-1} which is removing 13.76 tCO$_2$ha^{-1}yr^{-1} (Table 3.3). The water storage benefit of the forests per hectare was US$581 yr^{-1} which was worth US$32.31million yr^{-1} by the whole forest. In my study I found that the total value of soil erosion prevention provided by VSSPNP was US$22.21million yr^{-1} (US$399ha^{-1}yr^{-1}). The forest of VSSPNP plays an important role in nutrient cycling, equal to US$9.47million yr^{-1}. The value of nutrient cycling in unit area (ha) of forest is US$170ha^{-1}yr^{-1}. Four major components including NO_x, SO_2, HF and particulate are

considered in estimating the value of VSSPNP in regards to air quality improvement by absorbing these harmful elements. The value of air purification by the forest was estimated at US$56.21million yr^{-1} at a rate of US1010ha^{-1}yr^{-1}$. By removing harmful gases and particles from the atmosphere this forest not only reduces the cost of air purification, it also saves a large expenditure for public health and safety. The main attraction of VSSPNP is 'gibbons' along with the forest, indigenous people and birds. This makes the recreational value of the ecosystem to be US$0.02million yr^{-1} (Table 3.3).

Table 3.3: Major ecosystem services and their values of the conservation forest.

Services	Value (US$ yr^{-1})	
	Per hectare	Total (million)
Provisioning	32	1.76
Carbon storage	141	7.87
Water storage	581	32.31
Soil erosion prevention	399	22.21
Soil fertility improvement		
N	18	1.0
P	19	1.05
K	133	7.42
Subtotal	*170*	*9.47*
Air purification		
SO_2	9	0.48
HF	0.46	0.03
NO_X	1	0.03
Particulate	1001	55.67
Subtotal	*1010*	*56.21*
Recreational	0.37	0.02
Total	2334	129.84

3.3.2 Non-monetized value

3.3.2.1 Academic and non-academic knowledge

Table 3.4 shows that Ramachandra *et al.* (2012) analysed the methodological limitations of spatial and non-spatial models for predicting future deforestation in VSSPNP. Based

on a non-spatial model, deforestation would be close to 0.8% in first year while a non-spatial model shows no deforestation over five years. This valuable output would assist scientists to develop more precise methods for predicting deforestation rates worldwide. Ramachandra *et al.* (2012) also checked the viability of the REDD+ project in VSSPNP. Cash flow from REDD+ was found to be sensitive to the prediction of deforestation of the area, but they argued that it could deliver significant benefits.

Rawson and Bach (2011) discovered that geophagy is a common behaviour of douc langurs and silvered langurs which are predominantly arboreal primate species. These primates visit salt licks frequently and pass some time on the ground, where they are exposed to an increased risk of predation. These two species use the salt lick at different times of the day, and this opened up scope for research on the function of geophagy for colobines in VSSPNP. Moreover, this provided guidelines to determine measures for conserving these two taxa (Table 3.4).

Frechette (2014) explored the effects of species-specific seed dispersal patterns on seedling recruitment of *Microcos paniculata.* He found that the main dispersers were bulbuls (three species) and gibbons. Williams (2016) investigated how ecotourism and chainsaw activity impacts gibbon behaviour and calling in VSSPNP and found that both had potentially negative impacts on energy budgets. Nelson (2013) and Morley (2015) studied resource use by gibbons in VSSPNP and identified key feeding, calling and sleeping trees and how they are distributed in the forest (Table 3.4). All of these studies on gibbons are essential for a wider understanding of the ecology of this newly described species and designing better-informed conservation plans.

Table 3.4: Contribution of VSSPNP in generating academic knowledge.

References	Key area	Comments
Ramachandra *et al.* (2012)	Deforestation model	Analysed the methodological limitations of spatial and non-spatial models.
Rawson and Bach (2011)	Primate ecology	Discovered that geophagy is a common behaviour of douc langurs and silvered langurs.
Frechette (2014)	Primate ecology	Explored the effects of species-specific seed dispersal patterns.
Hill (2011)	Indigenous knowledge	Explored the local knowledge and uses of primates.
Geissler *et al.* (2012)	A new lizard species	Discovered *Lygosoma veunsaiensis* in VSSPNP.
Csorba *et al.* (2011)	A new bat species	Discovered a new bat species *Murina walstoni.*
Thinh *et al.* (2010)	A new gibbon species	Identified a new gibbon species (*Nomascus annamensis).*
Nelson (2013)	Primate ecology	Observed sleeping tree selection by northern yellow-cheeked crested gibbons.
Williams (2016)	Primate ecology	Explored predictors of the likelihood of northern buff-cheeked crested gibbons calling.
Morley (2015)	Primate ecology	Investigated key resource use of Northern yellow-cheeked crested Gibbon.

Hill (2011) conducted a survey to understand the local knowledge and uses of primates in the villages around VSSPNP (Table 3.4). The distance of the village from the forest and the level of knowledge on primates had a reverse relationship, which means that the people in the villages have the most knowledge about the primates. The majority of local people could recognize the primate species. Only in the Chinese village people were aware of few primates as they were involved in trading of those primate species. Pygmy slow loris was in high demand for traditional medicine, and macaques and gibbons were preferred for the pet trade. Hill (2011) also explained the local wildlife trading channel

as: indigenous people→ traders in the Chinese village→ Vietnamese in Ban Lung. These results would guide us in designing a program for primates and their habitat conservation.

Geissler *et al.* (2012) discovered a new species of lizard in VSSPNP named *Lygosoma veunsaiensis*. This is the third new species in the last two years to be discovered in the area. In 2011, a new bat species *Murina walstoni* was described by Csorba *et al.* (2011) a new gibbon species (*Nomascus annamensis) was identified by* Thinh *et al.* (2010) (Table 3.4). These highlight the uniqueness of the biodiversity of VSSPNP which is yet to be adequately documented.

The Australian National University runs a field school at VSSPNP to teach both undergraduate and postgraduate students effective and precise methods of data collection and build the capacity to utilize this data in biodiversity conservation plans and strategies. This course is also designed to enhance the adaptability of the future research in facing the likely challenges while studying forest vegetation and primates at field condition.

3.3.2.2 Network development

This forest has offered research opportunities and connected researchers from Oxford Brooks University, University of Florida, The Australian National University, Victoria University of Wellington, Zoologisches Forschungs Museum, Stockholm Environment Institute, Hungarian Natural History Museum, Harrison Institute, Royal University of Phnom Penh and Royal University of Agriculture of Cambodia. In providing logistic and financial support to those research and activities many non-academic organizations were also engaged notably Conservation International (CI), Fauna and Flora International (FFI), IUCN, Poh Kao, des tigres et des Hommes, Maisons Du Monde, McArthur Foundation, Ensemble Foundation, Critial Ecosystem Partnership Fund and Foundation Le PAL Nature. This is a great example of how a patch of forest can establish such

enormous research, network and familiarize a country worldwide in a new dimension. Working with international experts, research institutes, other NGOs, local community members and Cambodia's Forestry Administration have learned valuable research skills. These skills may help to provide future employment, research, and higher education on natural resource management.

3.3.2.3 Ethno-cultural

Indigenous communities have an intimate spiritual attachment with the forest. Animism is the dominant religion of the ethnic communities, apparently began with the influence of forest. Indigenous people, especially Lao and Kavet, believe that the spirits (locally called Araks) of their ancestors live inside the forest. Araks are believed to guide villagers for their livelihoods. Deforestation or conversion of forest for economic development enhances their concerns of losing protection from Araks, and this is often blamed for increased flood and drought. Every year each community organizes a village ceremony, in which every family must join. In the village ceremony every family prepares traditional Jai Wine (Figure 3.2a) and contributes rice or money to buy a buffalo to offer their ancestors' spirits during the ceremony. This celebration lasts three days, with traditional music, dancing, and singing. They believe that this ceremony would bring happiness to them.

These local people offer chicken, pig, and a jar of wine to the spirits before commencing any major event such as shifting cultivation, logging for building a house, weeding etc. If a man is bitten by a snake inside the forest it is considered as a punishment by the Araks for ill thoughts. If someone gets sick, they believe their ancestors are angry with that person due to cutting trees and wildlife hunting in the sacred places, or someone did something wrong to anger the spirits. They offer a chicken or pig or buffalo (based on the

decision by the religious leader) and wine to make their ancestors happy and to cure the patient, as well as to halt the spread of the disease (Figure 3.2b). After about three days if the patient does not get better than they consult doctors. The families who cannot afford hospital treatment wait longer to be cured. All these beliefs have been weakened; however, because timber traders offer chainsaws, money and political back-up to the villagers to engage them in illegal logging, and eventually the marginalised villagers have started to ignore their cultural beliefs in order to earn money. Thus, continuous deforestation has eliminated many of the cultural elements of local indigenous people, and this cultural loss may increase deforestation and hunting.

(a) (b)

Figure 3.2: a) Two indigenous villagers is drinking traditional wine. b) An indigenous man is praying to the Araks by sprinkling traditional wine.

3.3.3 Total value of ESS and its composition

The total value of ESS generated by VSSPNP is estimated at US$129.84million yr^{-1} (Table 3.3). Air purification is the largest contribution (43%) of VSSPNP followed by water storage (25%), soil erosion prevention (17%), soil fertility improvement (7%),

carbon sequestration (6%) and provisioning services (1.36%). The recreational value is not included in the composition chart (Figure 3.3) because this is too tiny to present as a percentage of total value. Nonetheless, the gibbons living in the forests have attracted tourists from around the world, and thereby increased the recreational value of the forest as a whole. Many tourists reported that if there were no gibbons they would not visit VSSPNP – i.e. the recreational value of the forest would be nearly zero. The community based ecotourism (CBET) program thus has enormous potential to increase the perceived value of the forest by tourists, which in turn can create actual increases in forest value, although to achieve this the program needs to expand.

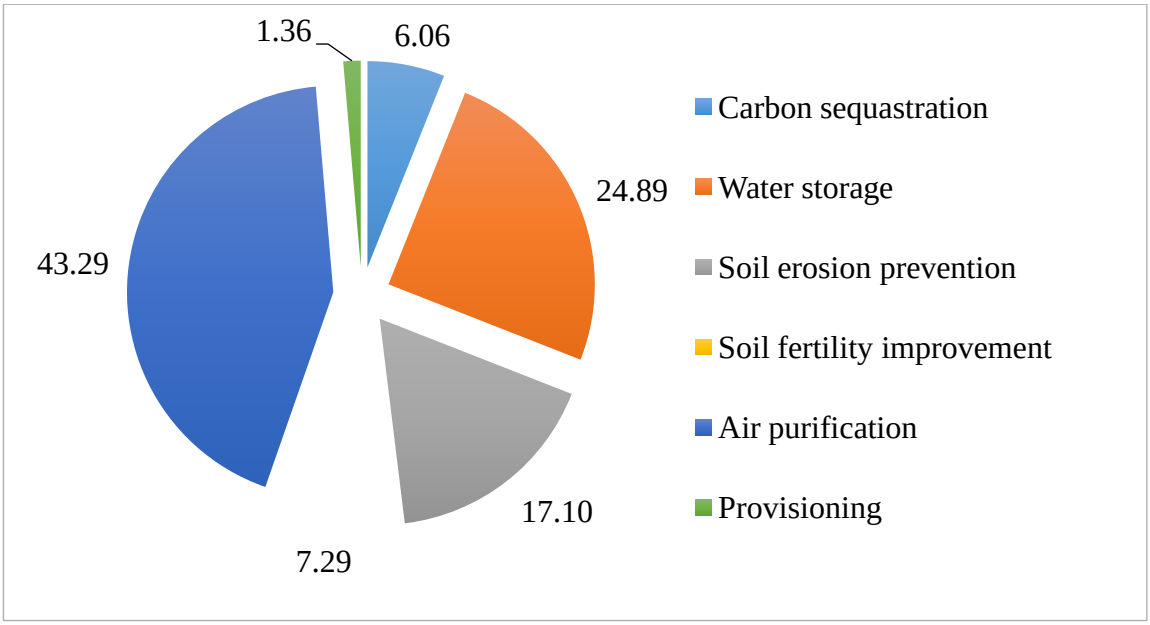


Figure 3.3: Contribution percentage of different ESS in relation to the total benefit.

3.4 Discussion

This research provides for the first time a valuation of a forest that while being largely unfamiliar to the international community is very significant in terms of richness of biodiversity. The value of the provisioning services supplied by VSSPNP was calculated to be US$1.76million yr^{-1}. This high economic contribution of the forest clearly

demonstrates the richness of the forest. According to the Ministry of Planning (2014) of Cambodia, the average annual income of the households in rural Cambodia is US$2793 yr^{-1}. My study, however, estimated an income of US3720yr^{-1}$ for only forest products from VSSPNP. This difference is mainly due to the high value timber in VSSPNP that is in great demand in Vietnam and China. Almost all the villagers were involved in illegal timber harvesting for both selling and self-consumption. The Chinese village near the forest area was the centre for timber trading of VSSPNP. Collectors reported that traders from this village supplied expensive chainsaws and money to continue cutting trees. Collectors then sold timber openly to the traders in the Chinese village, which were then transported out of the area, often in the middle of the night, to Ban-lung city and then to Vietnam and China. Such logging has already led to the disappearance of rosewood from the forest, which is also occurring in other forests in the region (Frewer and Chan, 2014). Without increased protection from international demand, it will be very difficult to slow down illegal logging practices in heavily corrupt Cambodia (Burgos and Ear, 2010). Destruction of VSSPNP would also worsen food security among indigenous people who are heavily dependent on VSSPNP for the collection of their most important food items including mushrooms, rattan shoot and fish (Kim *et al.*, 2008, Baja-Lapis, 2009) along with for the income produced through collecting malva nut and extracting resin from *Dipterocarpus spp*.

VSSPNP's sequestrated carbon was worth US$7.87million yr^{-1} by removing 13.76 $tCO_2ha^{-1}yr^{-1}$ from the atmosphere which is equal to total the emission from driving 536 automatic gasoline cars 100 km (Sullivan *et al.*, 2004). Thus, conservation of the forest would be a low-cost abatement option for CO_2 emission in the atmosphere (Kindermann *et al.*, 2008). The water storage benefit of forests per hectare was US581yr^{-1}$. Biao *et al.* (2010) also found the value of water conservation by the forests of Beijing is US855ha^{-}$

$^{1}yr^{-1}$ which is close the current study. In this study, I found that the total value of soil erosion prevention provided by VSSPNP was US$22.21million yr^{-1}. If the costs of off-site effects of soil erosion- siltation, water flow irregularities, reduction in irrigation, water pollution and etc. are considered, the total value of soil erosion would be very high (Ananda and Herath, 2003). Pimentel *et al.* (1995) estimate that the total investment for US erosion control is about US$8.4 billion per year which is a small price to pay in comparison to the total economic loss from soil erosion as every US$1 investment would save US$5.24. The forest of VSSPNP also played an important role in nutrient cycling, which equals US$9.47million yr^{-1}. Higher numbers of tree species accelerate nutrient cycling and related activities, which generates more ESS (Hooper and Vitousek, 1998, Gamfeldt *et al.*, 2013). To increase the nutrient cycling value it is essential to maintain the diversity of species VSSPNP.

Four major components including NO_x, SO_2, HF and particulate absorption are considered in estimating the value of VSSPNP in regards to air quality improvement. The value of air purification by absorbing harmful gases and particles was estimated US$56.21million yr^{-1}. Thus, this forest not only reduces the cost of air purification, it also saves large expenditure for public health and safety. Taking into account the health benefits of these harmful elements, Nowak *et al.* (2014) measured the value of the forest in rural areas of the US states is US$2.2billion yr^{-1}.

The main attraction of VSSPNP to tourists is 'gibbons' along with the forest, indigenous people and birds generating US$0.02million yr^{-1}. Xiang *et al.* (2011) reported snub-nosed monkey tourism project in Shennnongjia National Nature Reserve in China generated US$0.22millioin yr^{-1} after the same period of time of VSSPNP. While these revenues are scanty in comparison to the other successful flagship species tourism projects the projects are at the early stage of development. Given that Spenceley *et al.* (2010) found that in

2009 the Parc National des Volcans in Rwanda, gorilla based eco-tourism generated US$42.7million ecotourism at VSSPNP could generate significant funds if more effort is taken to improve the program. My finding that villagers close to the forest have improved knowledge of the primates, indicates that engaging these villagers in conservation activities may provide increased benefit from this increased knowledge base.

In addition to monetary value, VSSPNP served as an important research site for the study of a variety of species and for cooperation among academic researchers, NGOs and funding organizations. Researchers discovered new species including *Lygosoma veunsainesis*, *Murina walstoni* and *Nomascus annamensis* in VSSPNP which eventually created great research interests for the scientists of different parts of the world. This valuable output increased our knowledge of deforestation, carbon sequestration, ecology of douc langurs, silver langur, yellow-cheeked crested gibbons, and norther buff-cheeked gibbons, and indigenous use of primates. Moreover, field school programmes, and tourist visits created great awareness of conserving the forests both in Cambodia and other countries. These activities brought researchers from 11 research organizations and facilitated cooperation among 10 different funding organizations and NGOs working with the international experts, the capacities of local people were also improved. Thus, this forest has established an enormous research, network and familiarized Cambodia worldwide in a new dimension. Moreover, the forest has ethno-cultural and spiritual values to the indigenous people. This forest is essential to conserve to protect the cultural diversity of the area.

In monetary value, the ESS of VSSPNP generated US$129.84million yr^{-1}. In Mundulkiri and Koh Kong, the biodiversity corridor is worth US3815ha^{-1}yr^{-1}$ (ADB, 2010). Although there two more ESS are included in this study, per hectare value of VSSPNP's ESS (US2334ha^{-1}yr^{-1}$) suggests that the site is equally with other nationally valuable

ecosystems. The non-monetized values are also adding great importance to the local and national interests of Cambodia. Kubiszewski *et al.* (2013) also argued that if the intangible benefits of the ecosystem are included, the composition of the values changes drastically. This research demonstrates what a valuable resource we are going to lose if the current threats to the forests are not addressed immediately.

3.5 Conclusion

VSSPNP supplies benefits worth about US$129.84million yr^{-1}. Timber and many NTFPs values are traditional parameters which are used to compare the profitability of the forest ecosystem with agricultural land uses. My research suggests that this kind of cost-benefit analysis (CBA) in fact covers only 1.36% of the total value. If all the services can be accommodated in a total ecosystem value measurement, which I could not do due to data deficiency, the value of timber and NTFPs would account for even less. This significant information would be a valuable element in deciding trade-offs between forest conservation and utilization. Moreover, there are several services which cannot be monetized, and this also has a strong influence on the wellbeing of dependent societies.

Indigenous communities' cultural elements for life and livelihood are heavily influenced by the forest, and existing research at VSSPNP constitutes a valuable resource for the academic community as well as for non-academic communities worldwide. Yet little has been done thus far by the international community to effectively conserve the unique biodiversity of this region, and the total ESS values are fundamentally relevant for sustainable policy formulation as well as having large impacts on human wellbeing. In comparison to the value of the Mundulkiri and Koh Kong biodiversity corridor, the VSSPNP forest is equally important and in many cases more important than other protected biodiversity conservation areas in Cambodia. Recently, VSSPNP is declared as

'protected area' by the Cambodian government. These estimations would greatly support NGOs (e.g. Conservation International) in convincing the policy makers to ensure proper management of the valuable biodiversity hotspot.

The results obtained in this study regarding the value of various ESS present in VSSPNP can be extrapolated out to other forests in SE Asia with similar resource bases. This would assist in trade-offs for ecosystem conservation to establish palm oil and rubber plantation, mining, infrastructure development etc. in Cambodia or other countries. This kind of evaluation could provide essential guidelines Environmental Impact Assessment of any development project to achieve sustainable development. Moreover, increased awareness on the value of natural resource would motivate the politicians to follow sustainable development approach, popular short-term economic gain instead.

3.6 Limitations of the study

Data unavailability is one of the most common constraints for conducting research in developing countries (Asiedu, 2002, Kim Phat *et al.*, 2004, Mahar *et al.*, 2009). Due to lack of specific data I used benefit transfer method to collect the data required to measure the values of carbon storage, water storage, soil erosion prevention, soil fertility improvement and air purification. Although the underlying assumptions of the methods have some limitations, this study has been designed to use the best possible methods to measure the values of ESS. The assumptions I used in this study are mentioned in Table 3.1 which match the assumptions of the methods used. It was not the aim of the thesis to critically analyse all methods, but rather to use the best possible methods developed by other studies to determine ESS value of this forest and to put in context of values for other forests in the region. Ecological and geographical proximity were the priorities in collecting data from the secondary sources. Despite some shortcomings, benefit transfer

method is useful especially when the desired data are unavailable and this method can generate reasonably accurate results (Rosenberger and Loomis, 2000, Piper and Martin, 2001). However, these findings are valuable because roughly precise values are better than having no values at all.

Chapter 4

Potentials of Yellow Crested Gibbon tourism in Veun Sai-Siem Pang National Park as a recreational service for sustainable conservation

Abstract

This study aims to explore the potential impacts of a community-based ecotourism program (CBET) on human wellbeing in Veun Sai-Siem Pang National Park, north-eastern Cambodia. Data were collected by interviewing 36 tourists (before and after the visit) and 35 indigenous households. In a relatively short time span, the ecotourism project has gained attention and experienced on an average 63% growth in the number of tourists every year. Eco-tourists were mostly educated and from moderate-income groups (US$3000-5000/month) of developed nations. Based on visitor perceptions and interviews with local people, I found that gibbons increased the recreational value of the forest. There was a significant increase in the level of satisfaction of the tourists after visiting the site. I also found that people felt there was nobody helping them to improve their livelihoods before CBET started. But the activities related to implementing CBET were able to overturn this long-held perception. While CBET placed restrictions on illegal extractions, which was perceived as a significant reduction in peoples' freedom to continue their livelihoods, the restriction was not enough to stop most of the villagers from continuing those activities. People's intention for collective action and cooperation for conservation of the forest was significantly increased. Although all of the villagers were still engaged in cutting trees, the behaviour the ecotourism project intended to reduce eventually; people did avoid cutting down trees in the specific gibbon habitat. The overall conclusion from this study is that CBET has the potential to improve the

biodiversity protection within VSSPNP. However, it will take a long time for the project to increase the overall human wellbeing for Veun Sai's people unless the program is redesigned to address the specific demands of the people.

4.1 Introduction

Cambodia is a country of global conservation importance as it contains some of the largest remaining tracts of forest that were previously spread across much of Indochina and Thailand. As a result of these forests, this country also contains some of the largest species assemblages left in the region (Baird and Dearden, 2003, Sodhi *et al.*, 2010, Davis *et al.*, 2015). This country, however, has one of the highest rates of land-use change globally (Davis *et al.*, 2015, Hansen *et al.*, 2013); thus wildlife populations that do exist are at heavily reduced densities (Loucks *et al.*, 2009).

Deforestation in Cambodia has been a major issue since the 1980s when the Khmer Rouge's regime (1975-1980), which left much of the forest undisturbed, ended (De Lopez, 2001, Reimer and Walter, 2013). At this time, the new government instituted 'private concessions' to boost the struggling economy, which resulted in more than two million hectares of forest land being leased to foreign and domestic companies. Within these concessions, deforestation rates vary from 29% to 105%, which is overwhelmingly higher than the rate in land areas outside concessions and has left Cambodia with the highest deforestation rate in the world (Davis *et al.*, 2015).

Wildlife in Cambodia was also devastated during the civil conflict with the Khmer Rouge, which when coupled with massive scale hunting, widespread technological advancement, the emergence of illegal trade and policy changes (Loucks *et al.*, 2009) has left wildlife in a dire state. In forest-rich areas, where people are restricted in livelihood opportunities, cutting trees and hunting are considered to be profitable options for

subsistence (De Lopez, 2001). Thus, Southeast Asia has become a major hub for the wildlife trade which led exporting of more than 30 million wild animals between 1998-2007 (Nijman, 2010). Moreover, millions more traded locally are not often taken into account as there are no official records of those (Schlaepfer *et al.*, 2005). Protecting the wildlife and their habitats from overexploitation is a major challenge for conservationists. Without engaging local forest users properly and providing them alternative income options, no conservation effort would attain sustainability (Ameha *et al.*, 2014, Safa, 2004). One group of primates being particularly impacted by these forest losses is gibbons. Once abundant, *Nomascus spp.* gibbons are currently threatened by habitat loss and hunting across the Mekong regions including Vietnam, Lao PDR and Cambodia (Johnson *et al.*, 2005, Eames and Robson, 1993).

One strategy promoted worldwide as a viable strategy for conserving nature as well as generating incentives for local people to stop illegal activities is ecotourism (Xiang *et al.*, 2011). However, studies reveal there has been a mixed level of success amongst ecotourism projects as in many cases general ecotourism has failed to deliver the stated benefits to the local communities (Barrett and Arcese, 1995, Campbell, 1999). There is a growing trend in flagship species based tourism, as it can potentially increase the number of tourists and underpin long-term sustainability (Sharpley, 2007, Xiang *et al.*, 2011). Flagship species based tourism is also increasingly joined by the advertisements of other attractions; and thus encourages people to visit wildlife in their natural settings. This provides revenues for wider ecosystem conservation where flagship species reside. Moreover, this may also benefit areas at some distance from the flagship tourism site through raising of awareness of a species as a specific symbol of the natural ecosystem (Walpole and Leader-Williams, 2002, Williams *et al.*, 2000).

The core commodity of ecotourism is the 'beneficial experience' gained by the tourists. These experiences have elements to fulfil emotional or hedonic desire, while the supply and performance are dependent on the provider's capabilities (Johns, 1999). Tourists always have initial expectations like other customers from the services to be offered in a particular tourist destination. If the overall performance of the tour, during or after visiting, exceeds or at least meets most of the initial expectations, then the tourists are considered as satisfied (Akama and Kieti, 2003). Therefore, customer satisfaction has been increasingly becoming an important feature in the tourism and hospitality industry. Satisfied tourists are likely to recommend the destination to their friends and families, which is recognized as the most effective and cheapest way of promoting the tourism service (Reisinger and Turner, 2003). Furthermore, higher tourist-satisfaction usually contributes to increased numbers of tourists and higher revenues. As a result, there is an obvious positive correlation between tourist-satisfaction and the long-term economic success of the destination (Anders Gustafsson *et al.*, 2005). Moreover, tourists express their satisfaction by various ways; and thereby, strengthen the relation between the tourists and destination (Akama and Kieti, 2003, Anders Gustafsson *et al.*, 2005, Shoemaker and Lewis, 1999).

Veun Sai-Siem Pang National Park (VSSPNP) is an area in north-eastern Cambodia which has high biodiversity value with 60 species of mammals, 133 species of birds and 60 species of reptiles and amphibians (King *et al.*, 2016). It also contains significant populations of some of the world's most rare and endangered species including the 'Red-shanked douc langur (*Pygathrix nemaeus*)' and the 'Giant ibis (*Thaumatibis gigantean*)'. Primates of this area are of special conservation concern and of particular interest for conservation. The population of Northern yellow-cheeked crested gibbon (*Nomascus annamensis*) is believed to be the biggest population of the species in existence (Rawson

et al., 2012). While it is home to diverse wildlife species, VSSPNP is also home to several indigenous hill tribes and other people including Brao, Lao, Kavet, and Kinh (POH-KAO, 2012); however due to chronic poverty, illegal logging and poaching activities are threatening the site's ecological integrity which when paired with other human-induced ecosystem changes and general impacts of climate change, may result in catastrophic consequences (POH-KAO, 2012).

A community-based ecotourism project (CBET) was started in 2012 to protect primarily the gibbons of VSSPNP as well as other biodiversity and the forests within the area. Eco-tourists visited to VSSPNP generated a variety of services and benefits for communities and for tourists, which is described in the Millennium Ecosystem Assessment (MEA) framework as 'cultural service'. In this framework, cultural services such as recreational, aesthetic, spiritual, and educational were recognized as important for their influence on human wellbeing.

This study explores the level of tourist-satisfaction and benefits of the communities from ecotourism, focusing mostly on cultural services and human wellbeing (MEA, 2005). Despite the rich biodiversity, VSSPNP is largely unknown to the international community which means that the overall exposure and awareness about this site is low. As a result, there has been no study conducted to explore the potentials of gibbon based ecotourism in forest conservation as well as improving indigenous community wellbeing. This study aims to provide more information on the extent to which the CBET project contributes towards sustainable conservation goals of the National Park. Results will help to provide valuable guidelines for improving community-based natural resource conservation at this site and throughout Asia.

4.2 Methodology

4.2.1 Study site

VSSPNP is a 55,000ha forest in North-eastern Cambodia that is contiguous with the 320,000ha Virachey National Park which borders both Laos and Vietnam. The forest is characterized by patches of mixed deciduous and semi-evergreen forests (Chan *et al.*, 2004); and is located in the Veun Sai District of Ratanakiri Province and Siem Pang District of Stung Treng Province (Figure 4.1). VSSPNP has been listed as a Key Biodiversity Area in the World Biodiversity Database and is also part of the Virachey Important Bird Area (Chan *et al.*, 2004). Ecologically, the area is located within the Indo-Burma hotspot (Myers *et al.*, 2000). It is also a part of the 200 globally most important ecoregions, the Eastern Indo-China Dry and Monsoon Forest (Olson and Dinerstein, 1998) and the Critical Ecosystem Partnership Fund's (CEPF) Cambodia-Lao PDR-Vietnam Tri-border Forests priority corridor (Critical Ecosystem Partnership Fund, 2012). Within VSSPNP, four animal species are classified as Critically Endangered, 12 as Endangered, and 19 as Vulnerable on the IUCN Red List of Threatened Species. The remainder of the species are largely under threat due to illegal logging and poaching (Ramachandra *et al.*, 2012).

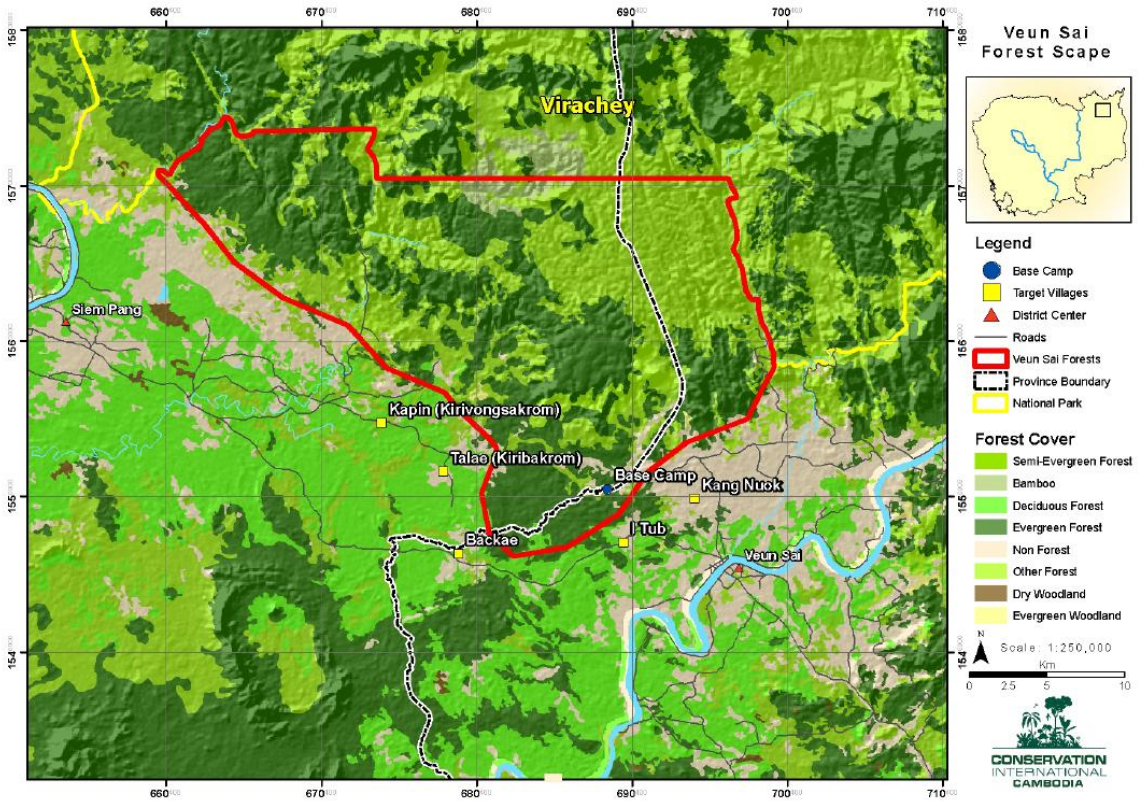


Figure 4.1: The Veun Sai-Siem Pang Conservation Forest (red boundary); source: Ramachandra *et al.* (2012).

4.2.2 Community-Based Ecotourism Project (CBET)

Ecotourism was initiated in 2012 at VSSPNP in order to gibbon's habitat conservation and bring revenue for surrounding communities to deter them from logging, wildlife poaching and clearing forest for agriculture. It was decided the tourism would occur in the area of the forest where one group of gibbons had been habituated, and would therefore likely be less adversely affected by the presence of people than the other unhabituated groups. In order to minimise impact on the gibbons, a limit of maximum six people in a group on any gibbon tour was set. Tourists are given transportation from Banlung city to VSSPNP and meals as part of their tour. On the gibbon viewing morning, tourists leave base camp at 4:30am and hike for approximately one hour to reach the gibbon spotting area where they wait for the gibbons to call, and then locate the group.

Tourists stay with the gibbons for an average of 1.5hr before returning to base camp and heading back to Banlung city.

4.2.3 Sampling and data analysis

To collect data on the demography of the tourists and their attitudes towards the CBET program, 36 tourists (out of 106 tourists) were interviewed twice- before their visit to see the gibbons and after the visit. The number of tourists visited in previous years and financial records were also collected from the official records of the management authority (Conservation International (CI)) and used to determine the distribution of financial benefits from CBET. The percentage of the tourists ranked a certain attraction has been calculated as (No. of tourists ranked the item*100/total No. of tourist). For example, if 31 tourists rank gibbons as first choice, then percentage of tourist= (31*100/36)= 86.11%. In addition, semi-structured questionnaires were used to interview 34 randomly selected household heads from three adjacent villages (I-Tub (N=16), Kang nuok (N=19) and Veun sai village (N=8)). This sample size was smaller than originally anticipated; however, some villagers refused to be interviewed due to the fear of giving information of forest resource harvesting. Moreover, many indigenous families use their own local languages and are not able to communicate in Khmer (national language of Cambodia). These limitations eventually forced us to reduce the intended sample size (7% of the total households) to the current 34. To explore the potential impacts of CBET on four general wellbeing criteria, including basic materials of good life, health and sanitation, security, and social relation and freedom of choice (MEA, 2005, Fisher *et al.*, 2014, Narayan *et al.*, 2000, Costanza *et al.*, 2007, Maynard *et al.*, 2015) I also conducted three focus group discussions (one per village) with at least five local people from each village consists of both CBET members and non-members. Based on interviews and discussion groups the effect of each criterion on the wellbeing was measured by using

scores varying from large to small impacts (Table 4.1). The overall scores were calculated by summing up the individual scores from each respective indicator within each criterion. The criteria and variables used to calculate the composite wellbeing were flagged by local indigenous people as important during interviews and group discussions. As no survey was conducted to obtain similar values before the establishment of CBET, I asked people to rate these variables using self-recollection from before CBET and then to report on current values. The differences regarding composite wellbeing were then compared between before and after the introduction of the CBET program using independent sample t-test in SPSS V22.0 software.

Table 4.1: Coded variables of human wellbeing of the study area.

Criteria	Variables	Codes
Water	a) Distance of water source	a) <0.5km= very high, 0.5km to1km=neither nor, >1m= very low
	b) Source of water	b) Own well = Very high wellbeing, Others well = High wellbeing, River/Stream = Low wellbeing
	c) Amount	c) Sufficient: Very high wellbeing, Moderate amount= Neither nor, 2-3 months short= High wellbeing
	d) Taste	d) Good= High wellbeing, Fair= Neither nor, Bad= Low wellbeing
	e) Cleanliness*	f) 1 to 5 scale where 1- very low wellbeing and 5- very high wellbeing]
	g) Health risks	g) High risk= Very low wellbeing, Don't know= Low wellbeing, Minor= High wellbeing, Not at all= Very high wellbeing
Food availability	a) Purchased	a) All= Very low wellbeing, Major amount= low wellbeing, Moderate amount= Neither nor, Little supplement= High wellbeing, Not all=Very high wellbeing.
	b) Chronic shortage	b) High= Low wellbeing, Moderate= Neither nor, Low= High wellbeing
	c) Sudden shortage	c) >3month= Very low wellbeing, 3months= Low wellbeing, >2 to <3months= Neither nor, 1 to 2months=

Criteria	Variables	Codes
		High wellbeing, <1month= Very high wellbeing
	d) food enough*	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
Good physical health	a) Physical weakness*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	b) Disease per year of family me	b) >15= Very low wellbeing, 10-15= Low wellbeing, 5-10= Neither nor, 3-5= High wellbeing, 1-3= Very high wellbeing
	c) Chronic diseases of family members	c) The more severe disease, the less wellbeing
Good mental health	a) Happiness*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	b) Self-esteem*	b) Codes are as (a)
	c) Stress*	c) Codes are as (a)
	d) Anger*	d) Codes are as (a)
Institutional protection	Institutions defend	Own family, NGOs, Public office= low
Social Freedom	a) Free to do what is preferred*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	b) Villagers respect each other's preferences*	b) Codes are as (a)
	c) Other restrict him/her*	c) Codes are as (a)
	d) Impartial justice exist	d) Yes= Very high wellbeing, No= Very low wellbeing]
	e) React against threat	
Economic freedom	a) Open market	Free market= Very high wellbeing, Restricted market=Very low wellbeing
	b) Produce freely	Yes= Very high wellbeing, No= Very low wellbeing
Trust and solidarity relations	a) Most of the people can be trusted *	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	b) Most of the people are willing non-financial help*	d) Codes are as (a)
	c) Most of the people are willing to help financially*	e) Codes are as (a)
Collective action and cooperation	a) How likely people work to protect ESS*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	b) How many people work in protecting forest	c) Most of the villagers= Very high wellbeing, Half of the villagers= High

Criteria	Variables	Codes
		wellbeing, Several/CBET member= Neither nor, Few= Low wellbeing, Nobody= Very low wellbeing
Groups and network	a) No. of group membership b) No. of close friends/families	a) 0- Very low wellbeing, 1-Low wellbeing, 2- Neither nor, 3-High wellbeing, ≥4- Very high wellbeing b) <5- Very low wellbeing, 5to <10- Low wellbeing, 10- Nether nor, >10to 15- High wellbeing, >15-Very high wellbeing
Social cohesion	Togetherness*	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
Personal security	How much security is for personal assets*	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
Certainty of employment	How much certain is to conduct ESS extraction*	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
Certainty of ESS availability	How much certain is to find and collect ESS*	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
Difficulty with emergency money	Easiness to receive	The easier to get loan from a person/organization, the higher wellbeing
Health or life insurance	Having an insurance	Yes= High, No= Low

Note: [a] data were collected on the scale of 1-strongly agree, 2-agree, 3- neither nor, 4-disagree, 5-strongly disagree. But for wellbeing the data were reversely coded i.e. 1→5 (very high wellbeing), 2→4 (high wellbeing), 3→3 (nether nor), 4→2 (low wellbeing), 5→1 (very low wellbeing).

4.3 Results

4.3.1 The Tourists

The majority of eco-tourists (34%) visited the site (N=36) to see the gibbons were 45 to 60 years old, while very few of them (14%) were more than 60 years of age. The remaining 23% tourists were below 30 years of age, which included the children of older tourists as well as younger backpackers. Interview data revealed that the tourists came to see primarily the gibbons and the forest because they care about nature and wanted to contribute to conservation activities. The highest number of tourists (34%) was the two lowest income groups (US$1000-3000 per month: 34% and US$3000-5000 per month:

31%), while the smallest number was the two highest income groups (US$5000-9000 per month: 3.1% and >US$9000 per month: 16%) (Table 4.2).

Table 4.2: Demography of the ecotourists who visited the CBET program in Veun Sai-Siem Pang National Park.

Features	% of tourists
Age	
15-30	22.9
30-45	28.6
45-60	34.3
>60	14.3
Education	
Primary	-
Secondary	5.7
College	5.7
Undergraduate	40
MS/MA	34.3
PhD	8.6
Study major	
Engineering	20.6
Medicine	8.8
NRM (Nat. Res. Mgt.)	8.8
Physical science	11.7
Arts/Social science	20.8
Business & economics	20.5
Law	8.8
Income (US$/month)	
1000-3000	34.4
3000-5000	31.3
5000-7000	15.6
7000-9000	3.1
>9000	15.6
Occupation	
Business	48.6
Private job	11.4
Govt. service	20
Retired	5.7
Others	14.3

Despite the lower income of the eco-tourists, the majority of them were highly educated with most of the people having graduated from university (83%), including 40% with undergraduate, 34% with masters and 9% with PhD degrees. Few tourists (5.7%) had secondary or College education. In terms of occupation, the highest number of tourists identified as businessperson (49%) followed by public servants (20%), part-time jobs (14%), and employees in private companies (11%), and few tourists (6%) were retirees. Equal numbers of tourists (21%) were found from engineering, arts/social science and business/economics backgrounds. The lowest number of tourists (9%) was those who had studied medicine, natural resource management or law (Table 4.2).

4.3.2 Benefit distribution

Based on the official records of the managing authority of the CBET project, tour operators received 70% of the total revenue from tourism at VSSPNP (US$14241yr^{-1}). The tourism managing authority (CI) makes no profit from this initiative, but they did work with CBET participants to determine how to best spend the 24% of funds (US$4962yr^{-1}). The authority also used 13% (out of 24%) of these funds to make improvements to the tourism program, and to fund community desired activities and projects including building of new bridge (Figure 4.2), repair existing roads and tourist site improvement. Members of the CBET program also received US$1197yr^{-1} for additional services they provided such as guiding, driving motorbikes and providing food, which constitutes 6%

Figure 4.2: Bridge funded by profits made by the CBET program in the first tourist season.

of the total revenue. This equates to US$2.53yr^{-1}household^{-1} across the villagers for direct payments; however, this does not factor in the other benefits received from CBET (Table 4.3, Figure 4.3).

Table 4.3: Benefit distribution of the gibbon eco-tourism of Veun Sai-Siem Pang National Park.

Beneficiaries	Total revenue (US$)	% of total revenue
Tour operator booking	14241	69.81
CBET expenses	4962	24.32
English Guide	1044	5.12
Site and community development	2721	13.33
Local household	1197	5.87
Cleaner	140	0.69
Transportation	1040	5.10
Porter	17	0.08
Total	20400	

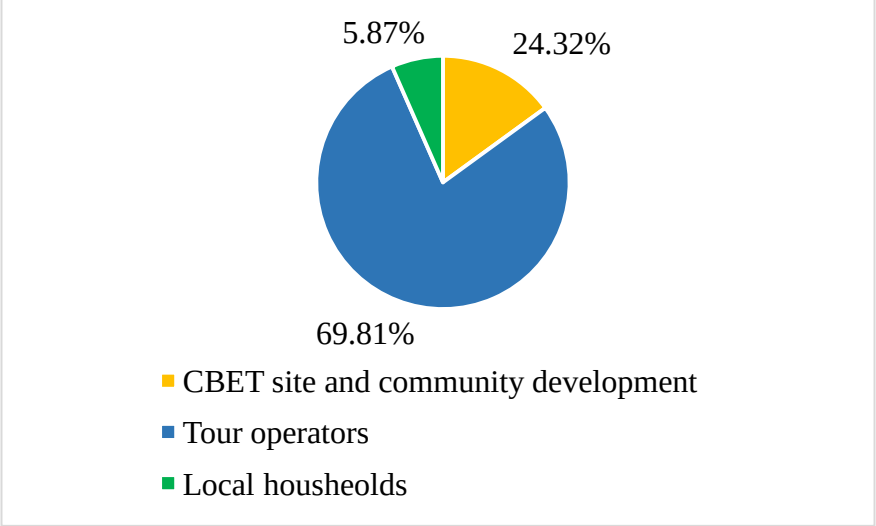


Figure 4.3: Benefit composition of local people and others from the CBET.

4.3.3 Rank of attractions

When comparing responses of tourists before and after their tour, there was a significant drop in interest in indigenous people and their culture which was the only significant difference in this comparison ($t = 3.162$; $p = 0.003$). Tourists mentioned that there was little scope to enjoy the indigenous culture during the tour. There was no significant difference in the ranking of gibbons as an attraction for the CBET after the tour compared to before. Eighty-six percent of tourists (n=31) listed gibbons as the primary reason they were interested in participating in the tour at the time of booking. After seeing the gibbons, 89% of tourists listed gibbons as the best attraction of the tour. Although some tourists ranked gibbons as their second favourite attraction (mainly behind the forest) at the site, after watching the gibbons in the wild all of them changed their mind stating the gibbons were their favourite thing about the tour and the trip was an exciting one (Table 4.4).

There was a significant change in the overall level of satisfaction between before (17%) and after visiting the site (78%) ($t = -6.677$; $p = 0.001$). Some tourists complained that the services provided were no- value for money. The tourists were perhaps responding to what are significant differences in overall tour operator fees, which lump together a series of offerings beyond the services provided by CBET and individual community members, which are the same regardless of tour-group. Irrespective of satisfaction level majority of the tourists (71%) were willing to recommend this tour to their family and friends which increased after the tour (82%). The remainder felt they may not recommend the tour due to the quality of transport, accommodation and/or food (Table 4.4).

Table 4.4: Comparing gibbons potentials in improving perception of the ecotourism program.

Items	% of tourists		*t*	*p*
	Before visiting site	After visiting site		
Enjoyment priority				
First				
Gibbons	86.1	88.9	-.572	.571
Forest	11.1	2.8	1.784	.083
Birds	0	0	-	-
Indigenous people	2.8	5.6	-1.000	.324
Second				
Gibbons	8.3	0	1.784	.083
Forest	58.3	72.2	-1.536	.134
Birds	16.7	8.3	1.357	.183
Indigenous people	8.3	2.8	1.435	.160
Third				
Forest	25	11.1	1.536	.134
Gibbons	2.8	5.6	-1.000	.324
Birds	33.3	16.7	1.972	.057
Indigenous people	19.4	19.4	-	-
Fourth				
Forest	2.8	2.8	-	-
Gibbons	2.8	2.8	-	-
Birds	25	25		
Indigenous people	30.6	8.3	3.162	**.003**
Fifth				
Birds	2.8	0	1.000	.324
Indigenous people	5.6	5.6	-	-
Level of satisfaction				
Very high	16.7	77.8	-6.677	**.001**
Moderately high	41.7	8.3	3.416	**.002**
Neither nor	27.8	11.1	1.784	.083
Moderately low	13.9	0	2.376	**.023**
Very low	0	2.8	-1.000	.324
Will you suggest others				
Yes	71.4	82.9	-1.673	.103
No	2.9	5.7	-1.000	.324
May be	25.7	11.4	1.963	.058

4.3.4 Changes in human wellbeing

4.3.4.1 Basic material of good life

There was no significant relationship found between the basic materials of the lives of the indigenous villagers and the implementation of the CBET program. As several streams were located inside the forest, water was available to most of the families within 100m, however, with the introduction of the CBET program, some families became more educated about clean water due to the sharing of knowledge with CBET officials. Those people started to use well water, which decreased reliance on natural water bodies. Water was sufficiently available throughout the year although there was a lower level of supply during the dry season. The majority of the people interviewed (82%) mentioned that the water tastes good or fairly good which was also the case in last five years. Cleanliness of the water also remained unchanged. Some families (12%) could afford to buy water from the market but most of the villagers (88%) relied on the free sources of water. More than half of the population (62%) reported that they did not suffer from any health problem due to water and a large number of villagers (30%) were completely unaware of any water-borne health issues (Table 4.5).

More than half of the people (68%) felt that for most of the time in a year they had an adequate amount of food. The rest of the families, however, reported they could not find enough food within the forest, thus were reliant on the market. Despite having adequate food, the majority of people also reported that they had been suffering from chronic food shortage at low (50%) to moderate (21%) levels. Food shortage for two to three months in the wet season was common across the families (68%). But 13% families suffered from food shortage for five months out of seven months of the wet season (Table 4.5).

Table 4.5: Comparison between the basic materials of life of between before and after community based Yellow Crested Gibbons tourism.

Elements	% of households		*t*	*p*
	Before CBET	After CBET		
Water for drinking/cooking				
Distance from source of water				
Very close	38.2	41.2	1.000	.323
30-50m	14.7	11.7	.000	1.000
50-100m	47.1	47.1		
Source of water				
Own well	38.2	41.2	1.000	.323
River/stream	47.1	44.1	-1.000	.323
Others' well	14.7	14.7	-	-
Availability				
Sufficient	79.4	79.4	-	-
Moderately sufficient	20.6	20.6	-	-
Taste of water				
Good	76.5	76.5	-	-
Moderate	17.6	17.6	-	-
Bad	5.9	5.9	-	-
Cleanliness				
Agree strongly	55.9	52.9	-1.000	.323
Agree somewhat	5.9	5.9	-	-
Neither nor	23.5	26.5	1.000	.323
Disagree somewhat	14.7	14.7	-	-
Disagree strongly	0	0		
Need to pay				
Yes	11.8	11.8	-	-
No	88.2	88.2	-	-
Health risk of the water				
High	0	0		
Minor	8.8	8.8	-	-
Not at all	61.8	61.8	-	-
Don't know	29.4	29.4	-	-
Food				
Generally enough to feed family				
Agree strongly	47.0	35.3	.443	.660
Agree somewhat	29.4	32.4	-1.000	.323
Neither nor	8.8	8.8	-	-
Disagree somewhat	2.9	8.8	-1.433	.160
Disagree strongly	11.8	14.7	-1.000	.323

Elements	% of households		*t*	*p*
	Before CBET	After CBET		
Purchasing food				
Major amount	35.3	41.2	1.433	.160
Moderate amount	38.2	32.4	-1.433	.160
Little supplement	5.9	11.8	1.433	.160
Not at all	17.6	11.8	-1.433	.160
All	2.9	2.9	-	-
Chronic food shortage				
Low	50.0	50.0	-	-
Moderate	20.6	20.6	-	-
High	8.8	8.8	-	-
Not at all	20.6	20.6	-	-
Sudden shortage				
Not at all	17.6	17.6	-	-
<3 months	67.7	67.7	-	-
3-5 months	2.9	2.9	-	-
>5 months	12.7	12.7	-	-

4.3.4.2 Health and sanitation

There was no significant difference observed in health and mental conditions of the people when comparing their perceptions of these conditions before and after CBET. With the initiation of CBET, some people gave up illegal activities in the forest, although a large number of households still continued these activities. This has created some self-reported problems including physical conflicts, food shortages, reduced incomes and shifts in both physical and mental health. No changes were reported in physical strength or the frequency of seasonal diseases. There was a wide level of unawareness about health and sanitation across society and none of the families in the village used a sanitary toilet. Many of them had little (35%) or no knowledge (before: 47%, after: 44%) about health and sanitation.

Table 4.6: Comparing health and sanitation between before and after community based Yellow Crested Gibbons tourism.

Elements	% of household		*t*	*p*
	Before CBET	After CBET		
Physical health				
Physically feels weak				
Strongly agree	55.9	55.9	-	-
Agree some extent	8.8	8.8	-	-
Neither agree nor disagree	14.7	14.7	-	-
Disagree some extent	11.8	11.8	-	-
Strongly disagree	8.8	8.8	-	-
Diseases (frequency/yr)*				
Male	3.76	3.82	.627	.535
Female	5.28	5.28		
Children	4.36	4.43	1.000	.326
Chronic diseases/health issues				
Male				
Gastro pain	3.4	6.7	1.000	.323
Hypertension	3.4	3.3	-	-
Tooth gum pain	3.4	3.3	-	-
Female				
Gastro pain	3.4	3.4	-	-
Migraine	17.2	17.2	-	-
Asthma	3.4	3.4	-	-
Children	0	0		
Health awareness				
Toilet facility				
Sanitary	0	0	-	-
Unsanitary	100	100	-	-
Knowledge of health				
Very low	17.6	17.6	-	-
Low	17.6	17.6	-	-
Moderate	8.8	8.8	-	-
Not at all	47.1	44.1	-1.000	.323
Only malaria	8.8	11.8	1.000	.323
Mental health				
Generally feels happy				

Elements	% of household		*t*	*p*
	Before CBET	After CBET		
Strongly agree	61.8	61.8	-	-
Agree some extent	5.9	5.9	-	-
Neither agree nor disagree	11.8	11.8	-	-
Disagree some extent	20.6	20.6	-	-
Self-esteem is high				
Strongly agree	47.1	47.1	-	-
Agree some extent	8.8	8.8	-	-
Neither agree nor disagree	17.6	17.6	-	-
Disagree some extent	2.9	2.9	-	-
Strongly disagree	23.5	23.5	-	-
Regularly stressed				
Strongly agree	26.5	26.5	-	-
Agree some extent	38.2	41.2	1.000	.323
Neither agree nor disagree	14.7	11.8	-1.000	.323
Strongly disagree	20.6	20.6	-	-
Regularly angry				
Strongly agree	29.4	29.4	-	-
Agree some extent	20.6	20.6	-	-
Neither agree nor disagree	2.9	2.9	-	-
Disagree some extent	11.8	11.8	-	-
Strongly disagree	35.3	35.3	-	-

Mental health including happiness, stress, self-esteem and anger levels was identical before and after CBET's introduction and a majority (68%) of the villagers were happy with their life and livelihood. In terms of anger the respondents were almost equally divided (i.e. 50% felt angry most of the time and 47% experienced a low level of anger). People stated that social injustice, lack of money, and lower availability of ecosystem services compared to several years ago were the primary causes of their anger. Moreover, 56% of the indigenous participants felt stressed with 65% at high levels of stress and only

21% was at low stress. Self-esteem was found high across more than half of the villagers (56%) while only a quarter of the total households were in low self-esteem (Table 4.6).

4.3.4.3 Freedom of choice

Local people reported that they felt there was nobody to protect their livelihoods but themselves. After the introduction of CBET, however, significantly more people (an increase from zero percent to 12%) stated that the NGO that manages the CBET program (CI) was there to help in defending their livelihoods ($t = 2.082$; $p= 0.012$), which may be a result of the co-operation between the government and CI which eventually increased people's confidence on the NGO than before CBET. Government interference in collecting resources (illegal) was also significantly increased ($t = 2.623$; $p = 0.012$). Before the introduction, of the CBET program 62% of people were able to freely collect non-timber forest products (e.g. resin, malva nuts, mushroom, bamboo shoot etc.) from the forest. But after the CBET program, this was significantly reduced (41%) due regular patrolling by rangers (both CBET and government) to stop illegal activities, primarily luxury timber and wildlife extraction ($t = 2.876$; $p = 0.006$). It was reported that people's abilities to bribe patrolling staff, if caught with illegal products, were significantly increased after CBET (before: 18%, after: 38%) ($t = -2.876$; $p = 0.006$). None of the collectors of non-timber forest products mentioned any violent conflict took place between collectors and rangers. But rangers separately reported some rare incidents of brutal attacks from villagers especially during logging valuable trees from VSSPNP. In other variables within the freedom of choice category, there was no significant difference found before and after CBET (Table 4.7).

Table 4.7: Comparing freedom of choice between before and after community based Yellow Crested Gibbons tourism.

Components	% of households		*t*	*p*
	Before CBET	After CBET		
Institutions for freedom of choice				
Organization/person to defend right				
Own family	97.1	85.3	-2.082	.044
NGOs	0	11.8	2.082	.004
Villagers	2.9	2.9	-	-
Impartial judiciary exists	94.1	94.1	-	-
Organization to restrain the right				
Nobody	94.1	64.7	-2.623	.012
Government authorities	5.9	11.8	2.623	.012
NGO and Government authorities	0	23.5		
Social freedom				
Free to do what is preferred	100	100	-	-
Members respect each other's preferences				
Agree strongly	73.5	73.5	-	-
Agree somewhat	20.6	17.6	-1.000	.323
Neither nor	0	2.9	1.000	.323
Disagree somewhat	0	0		
Disagree strongly	5.9	5.9	-	-
Others restrict my livelihood				
Agree strongly	35.3	35.3	-	-
Agree somewhat	14.7	14.7	-	-
Neither nor	0	0		
Disagree somewhat	5.9	5.9	-	-
Disagree strongly	44.1	44.1	-	-
Punishment for damaging others' rights				
Yes	97.1	100	-1.000	.323
No	2.9	0	1.000	.323
React against any threat				
Money	17.6	38.2	-2.876	.006
Flee	11.8	14.7	-2.082	.044
Apologise	8.8	5.9	1.000	.323
No need to react	61.8	41.2	2.876	.006
Economic freedom				
Open markets for everyone	100	100	-	-
Can produce free whatever wants to	100	100	-	-
Can sell the forest resources freely	83.3	76.7	1.433	.160

There was also no improvement found in terms of social respect among community members before and after CBET. Although respect was very common across the society, the moral values were reportedly had been degraded. There were no restrictions indigenous people experienced from their own populations; however, resin theft was reported as a conflict with outsiders, which sometimes happened inside the forest. Despite some discontent on the social justice system related to the uneven treatment of those engaged in illegal activities by the authorities, they mentioned that there was an improvement in punishing harmful person/families due to increased overall empowerment.

4.3.4.4 Social relation

I found a significant increase (before 3%, after: 24%) in the likelihood of people collectively acting to protect the forest ($t= -2.479$; $p= 0.018$). Before CBET nearly half of the population (47%) did not support conserving the forest but after the project, this figure significantly dropped to less than half that number (21%) ($t = 2.467$; $p = 0.018$). There was also a significant change noticed in the number of people would come forward to implement sustainable conservation programs. A significantly higher number of indigenous people (24%) supported the conservation activities and sustainable collection than the commencement of the project ($t = -3.122$; $p = 0.003$). Before the CBET program people did not even think of conserving the forest but now a significantly higher number of people (77%) realized that they needed the forest to be conserved for their own wellbeing ($t = -8.062$; $p = 0.001$) (Table 4.8).

Table 4.8: Comparing good social relation between before and after community based Yellow Crested Gibbons tourism.

Components	Before CBET	After CBET	*t*	*p*
Trust and solidarity relations (% of HH)				
Most of the people can be trusted				
Strongly agree	79.4	76.5	-	-
Agree some extent	8.8	8.8	-	-
Neither agree nor disagree	8.8	5.9	.572	.570
Disagree some extent	2.9	5.9	-1.000	.323
Strongly disagree	0	2.9	-	-
Many people are willing to financial help				
Strongly agree	17.6	17.6	-	-
Agree some extent	29.4	17.6	1.433	.160
Neither agree nor disagree	32.4	38.2	-.703	.486
Disagree some extent	11.8	14.7	-.443	.660
Strongly disagree	8.8	11.8	-1.000	.323
Most of the people willing for non-financial help				
Strongly agree	67.6	61.8	-1.433	.160
Agree some extent	23.5	20.6	-.572	.570
Neither agree nor disagree	5.9	11.8	1.433	.160
Disagree some extent	2.9	5.9	1.000	.323
Strongly disagree	0	0	-	-
Collective action and cooperation (% of HH)				
How likely people work for protecting forest				
Very likely	0	0		
Somewhat likely	2.9	23.5	-2.479	.018
Neither nor	41.2	44.1	-.274	.785
Somewhat unlikely	8.8	11.8	-.572	.570
Very unlikely	47.1	20.6	2.467	.018
How many people work together in protecting forest				
Several/ CBET member	0	23.5	-3.122	.003
Few	2.9	76.5	-8.062	.001
Nobody	97.1	0	13.559	.001
Groups and network (No.)				
Group membership	1	1.60	6.093	.001
Close friend/members	4.76	5.85	-3.030	.005

Components	Before CBET	After CBET	*t*	*p*
Social cohesion (% of HH)				
Togetherness				
Very close	50.0	41.2	.829	.412
Somewhat close	20.6	23.5	-.374	.711
Neither distant nor close	17.6	20.6	-.330	.743
Somewhat distant	2.9	8.8	-1.433	.160
Very distant	8.8	5.9	1.000	.323
Families sharing ESS (No.)	1.85	1.97	-1.161	.254

Within the indigenous communities, there were some informal groups that formed socially with the purpose of collecting ESS. It was found that before CBET each household head was a member of at least one group but after the CBET program, some of them became CBET member which significantly increased their group membership to a mean of 1.6 groups (t = 6.093; p= 0.001). There was also a significant increase in the number of close members or friends (before: 4.76, after: 5.85) which was a direct effect of participation in the CBET program (t = -3.030; p= 0.005). It was also found that significantly more people were willing to protect the forest after the introduction of CBET as the number of people who had no intention to protect the forest dropped from 98% to zero percent (t = 13.559; p = 0.001). After the introduction of CBET, there was no significant difference observed in trust and solidarity relations among the villagers (Table 4.8).

4.3.4.5 Security

There was no significant difference observed in security conditions (personal, livelihood, economic security) within the communities before and after CBET. People reported that personal, livelihood and financial security were some of the most important criteria for their wellbeing. The indigenous neighbourhood was very safe for the majority of the people (85%). However, some rare incidents including stealing or mugging happened in nearby village markets or towns. After the introduction of the CBET program, there was

a reduction (6%) in their level of livelihood certainty. People mentioned that it was because of two main reasons- firstly, the restriction imposed by CBET in cutting trees and hunting; secondly, the reduced availability of the forest products due to a loss of trees and forest degradation caused by the ongoing logging and hunting. Similarly, most of the villagers (86%) could secure ESS from the forest but because of the high level of competition and lower productivity of ESS, some families (14%) failed to secure any ESS.

In many cases, collectors especially timber, resin collectors often had to spend several nights inside the forest, as those were no longer available near the locality. It was rare to have health insurance in rural indigenous people. Only 3% were covered by health/life insurance policy. In need of emergency money they (21%) were increasingly dependent on neighbours than before (9%) instead of relatives (before: 33%, after: 24%). Few families (3%) loaned money from the local lenders in the Chinese village with interest or in exchange for a domestic animal (e.g. pig, calf, and duck). More than quarter of the families mentioned that they never borrowed money but still suffer. CBET was able to improve the economic security by providing interest-free loan to the people (15%) who otherwise had to go to other sources (Table 4.9).

Table 4.9: Comparing security level between before and after community based Yellow Crested Gibbons tourism.

Components	% of households		*t*	*p*
	Before CBET	After CBET		
Personal security is good				
Strongly agree	85.3	85.3	-	-
Agree some extent	0	0	-	-
Neither agree nor disagree	11.8	11.8	-	-
Disagree some extent	0	0	-	-
Strongly disagree	2.9	2.9	-	-
Livelihood is certain				
Strongly agree	88.2	82.4	-	-
Agree some extent	11.8	17.6	-	-
Neither agree nor disagree	0	0	-	-
Disagree some extent	0	0	-	-
Strongly disagree	0	0	-	-
Certainty of ESS				
Strongly agree	86.2	86.2	-	-
Agree some extent	0	0	-	-
Neither agree nor disagree	13.8	13.8	-	-
Disagree some extent	0	0	-	-
Strongly disagree	0	0	-	-
Health/life insurance				
Yes	2.9	2.9	-	-
No	97.1	97.1	-	-
Emergency money				
Neighbours (without interest)	8.8	20.6	-1.000	.323
Relatives (without interest)	32.8	23.5	-1.778	.083
Local lenders (with interest)	0	2.9	1.000	.323
Family members	23.5	23.5	1.433	.160
CBET	0	14.7	1.000	.323
Bank	8.8	0	1.000	.323
Never borrow	26.5	26.5	-	-

4.3.4.6 Composite wellbeing score

After introducing the CBET program the social freedom of choice of the households was significantly reduced ($t = 3.020$; $p = 0.005$). Participants explained that CBET gave them alternative income sources and opportunities to work in groups but the effect was too small to improve their society. Respect to each other across the villages was reduced more than before due to higher competition for the resources. Moreover, merchants from Chinese Village adjacent to the forest supply all the money and chainsaw to many villagers to continue cutting trees which allowed them to bribe some officials to avoid confiscation.

Wellbeing regarding food and nutrition was reduced significantly after the CBET program ($t = 3.419$; $p = 0.002$). This is likely due to the fact that when the CBET program was initiated people were already in a high level of food insecurity due to the scarcity of wild food items from the forest. Due to the initiation of CBET people expected a big increase in income and access to food resources. However, the income received from CBET was too small to substantially increase food security which entails a difference between the expectations of the people and of the tourism authority. CBET was successful in significantly increasing collective action and cooperation by supporting the formation of groups through the inclusion of all participants to support the transportation, guiding, catering the tourists and patrolling the forest ($t = -8.217$; $p = 0.005$) (Table 4.10).

Table 4.10: Comparing composite wellbeing score of before and after community based Yellow Crested Gibbons tourism.

Wellbeing criteria	Before CBET				After CBET				*t*	*p*
	Min	Max	Mean	SD	Min	Max	Mean	SD		
Social Freedom	3.60	5.00	4.31	0.376	3.40	5.00	4.25	0.382	3.020	.005
Economic freedom	5	5	5.00	0.000	5	5	5.00	0.000	-	-
Institutional protection	3	3	3.00	0.000	3	3	3.00	0.000	-	-
Water for domestic use	3.17	4.83	4.13	0.507	3.17	4.83	4.14	0.533	-.274	.786
Food availability	2.33	4.67	3.60	0.671	2.00	4.33	3.09	0.673	3.419	.002
Good physical health	2.40	5.00	4.47	0.648	2.40	5.00	4.48	0.628	-.665	.511
Good mental health	2.00	4.75	3.52	0.724	2.00	4.75	3.53	0.720	-1.00	.325
Personal security is good	1.00	5.00	4.65	.9172	1.00	5.00	4.65	.9172	-	-
Certainty of ESS availability	3.50	5.00	4.84	0.403	3.50	5.00	4.84	0.403	-	-
Emergency money	3.00	5.00	4.29	0.871	2.00	5.00	4.65	0.774	-1.875	.070
Trust and solidarity relations	3.00	5.00	4.19	0.587	1.33	5.00	4.01	0.831	.776	.443
Collective action and cooperation	1.00	2.50	1.51	0.500	1.50	3.50	2.47	0.563	-8.217	.005
Social cohesion	1.00	5.00	4.00	1.279	1.00	5.00	3.85	1.234	.681	.500

4.4 Discussion

4.4.1 Tourism

In a relatively short time span (2012-present) the CBET program at VSSPNP has gained attention and experienced on an average 63% growth in the number of tourists every year (from 31 in 2012 to 205 in 2015). Gibbon tourists were primarily aged from 30 to 60yrs and had a college or higher level of education. Similar results have been found in Belize and the USA where it is reported that eco-tourists are less than 40 years of age and well educated (Meric and Hunt, 1998, Palacio, 1997). Eco-tourists were mostly people with moderate incomes based on developed country standards. Kerstetter *et al.* (2004) also argued that eco-tourists are generally in the higher range of income, but that the richest groups tend not to participate as eco-tourists, It has been suggested that high-end income groups who are considered as powerful elites should be a target group for ecotourism because often they may be able to use their concern for the natural environment and conservation, to put pressure the governments to minimize ecosystem degradation (Fairbrother, 2013, Holmes, 2010). With only a very small number of tourists being from high-income status at VSSPNP, this would be hard to do. May be for this reason, people from the highest income brackets prefer to spend their holidays in luxury resorts and cites which are mostly absent in the vicinity of ecotourism areas. In terms of occupation, the highest number of tourists to visit VSSPNP were businesspeople. The most common reason that these people listed to visit the site was to be able to inform the business community about the ways people can contribute to nature conservation while making a profit. They believed this would also help reduce the stigma that business people do not care about the environment.

My results found that the gibbons increased the value of VSSPNP and there was a significant improvement in the level of satisfaction of tourists after visiting the site. All the tourists mentioned that they would not have visited VSSPNP if there was no gibbon because forests are available elsewhere in the world. Thus, gibbons are seen as an iconic species that can potentially increase the number of visitors and can underpin sustainable conservation of the ecosystem (Sharpley, 2007). Flagship species, such as this, could play a key role in marketing ecotourism site and motivating tourists to visit the place. Gradually other endangered species can also be better highlighted under the CBET program to attract a wide range of tourists and promoting the idea of flagship species would be possible (Home *et al.*, 2009, Williams *et al.*, 2000). In Shennongjia National Nature Reserve of China, snub-nosed monkeys (*Rhinopithecus roxellana*) are used as a flagship species for conservation, which has led to increased tourism revenue as well as an increase in the way government officials view biodiversity conservation. Senior politicians have visited the site to view the monkeys and as a result put more regular and special funding into conserving the whole park (Xiang *et al.*, 2011).

4.4.2 Human Wellbeing

The composite wellbeing score of feeding condition was significantly reduced which was reportedly due to CBET nor yet providing enough income to individual households to make a substantial difference in standing food shortage. The implementing authority intended to provide alternative employment to the local people by CBET and thereby reduce their dependency on illegal logging and hunting for generating income. But the villagers expected the rise in income to occur rapidly resulting in quick improvement of their family conditions including increased income, higher food security, improved access to safer water. Although there was some success based on the standards of the managing authority, including the building of new roads and an increase in local

development, the local indigenous villagers did not necessarily view this success at the same level because of the slow growth of the tourism resulted in nominal growth to the household economy. Therefore, it is essential to address the demands and expectations of the direct beneficiaries of a community-based conservation project like CBET (Sheppard and Meitner, 2005, Menzel and Teng, 2010) at the point of initiation to manage any disappointment that may result from unrealistic expectations.

There was a significant shift in the belief that NGOs would work in favour of their livelihoods after CBET. Dressler and McDermott (2010) reported that community based conservation programs raise the issue of indigenous rights that lead more people-friendly decision by the respective authorities. After CBET people lost significantly some elements of social freedom to continue the livelihoods, mostly due to greater restrictions on illegal activity. However, the villagers were able to continue their preferred livelihood activities without any major confrontation. This is because it was primarily the illegal income earning generating activities that were lost or restricted with the introduction patrolling by CBET rangers with accompanying an increase in enforcement provided by Forestry Administration. Gaveau *et al.* (2007) also showed that despite the protection measures people find their ways to continue both legal and illegal extraction of forest resources. There was no change in the physical health of local villagers, except for a small increase in chronic health issues of adult male members of the families, which does not have any specific link to tourism. Remote indigenous people are highly vulnerable to diseases due to the lack of education and healthcare service (McDonald *et al.*, 2010). Incorporating the activities addressing the health and sanitation issues, CBET could provide added benefits for the people it is working with, perhaps making them more pro-active and engaged in forest conservation.

After CBET there was a slight decrease in trust and solidarity relations, and social cohesion among the villagers. This was due to conflicts about illegal activities. Cattell (2001) demonstrated that spending less time with other people increases isolation which affects the solidarity of local people. Due to CBET, people's intention for collective action and cooperation for conservation of the forest significantly increased. Creating different social groups through the management authority of CBET to run the activities of the program has enhanced collaboration among them. Varughese and Ostrom (2001) also argued that formal and informal institutions benefit the participants and lead strong collective action. It was mentioned that when the project first started many indigenous people stood against the initiative from the fear of restraint their livelihood activities in the forest. Because of CBET, there was a widespread belief that if anyone cut trees in the gibbon habitat, they will disappear and tourist would not come which will affect their income. Although all the villagers were engaged in cutting trees, they avoided the gibbon habitat. This perception was created due to the requests from the participants in the villages. However, threats to the gibbons exist in the form of loggers using chainsaws and hunters using guns for bush-meat elsewhere around the site. Traders of the Chinese village in the vicinity of the forest supply all the tools and equipment, and money to the villagers to cut trees as well as maintain financial relation with the local leaders to continue the illegal timber logging. To patrol the forest only three persons were employed by the government. CI employed two community persons to support Forestry Administration patrolling the gibbon protection site of VSSPNP. A lack of manpower, political and administrative support puts rangers in a dilemma which lead government officials to limit themselves to the activities that will secure their jobs by compromising the effective forest conservation intervention. This demonstrates that massive effort is required to solve the complex problem of forest destruction in VSSPNP.

Therefore, CBET has the potential to improve the wellbeing of the people but yet needs to make a significantly positive change. The current program has not robustly addressed the human wellbeing, instead, the premise was the ecotourism would attract tourists and income generated from CBET would be an incentive for conservation and an economic alternative to destructive livelihood activities in the forest; thereby, increased income will eventually enhance wellbeing of the participants. In order to fulfil the objective of the program, improvements need to be made such as increasing enforcement effectiveness to secure the forests and therefore continue to attract tourists. In terms of its results of benefitting human wellbeing, the CBET program was still unable to address the key demands of the people. The notion of development where increased income enhances wellbeing, has not been able to create promising results, and more importantly, such approach is subject to long-term investment commitment which is often not the case (Kiss, 2004, Salafsky *et al.*, 2001, Stone and Wall, 2004, Stronza, 2009). My study also estimated that it will take very long time to increase the wellbeing of the people if there is only the sole focus on increasing household income. There are different components of wellbeing which could be achieved by the existing program activities and with a minimum investment for instance, installing common water facility, educate the villagers about nutrition, health and sanitation, and training for alternative employment etc.

4.5 Conclusion

Gibbon ecotourism was able to bring young and middle-aged affluent people to care about nature. There was a big number of tourists who had no environmental or natural resoruces management background in education or profession. Gibbons tour was very potential to greatly increase the value of the forest. However, CBET has largely failed to improve the basic materials of good life to the people around the forest as assessed under the MEA framework, especially safe drinking water and adequate food. Due to CBET,

indigenous people lost some freedom to perform their livelihood activities, in particular, illegal activities. However, they continued their legal or illegal harvesting from the forest by often negotiating with money or confronting the enforcing personnel. Thus, ecotourism has thus far had very little or no effect on the over exploitation and illegal harvesting of ecosystem services of the forest. Similarly, there was very lilttle or no change in physical health and sanitation and mental health of the communities. High sense of security including personal safety, a certainty of livelihood activities, and a certainty of ESS availability in the forest remained unchanged over the period of CBET program. CBET has accelerated the intention for collective action and cooperation for conservation of the forest was significantly increased. After CBET there was a slight decrease in trust and solidarity relations and social cohesion—largely due to on-going competition for resources and tensions between those wanting to protect forests for subsistence and those wanting to exploit them for income. My research suggests that CBET requires to include community develeopment issue more extensively in order to achieve sustainable conservation goals.

4.6 Limitations of the study

Many potential participants declined to be interviewed as they were reluctant to give information perhaps because of involvement in illegal logging and haunting. As there was no similar kind of study conducted in this site, self-recollection was used to get the data of ‘before CBET’ program. Although the sample size is apparently small, it represents 34% of the total population size. Statistical consulting unit of ANU has suggested that this is a sufficient sample size to representing the whole tourist population. The study was conducted for a year due to limited fund, time and other supports. By overcoming the obstacles faced during the field study, a research for a longer period of time with a higher sample size could generate more interesting outcomes.

Chapter 5

The interactions between livelihood capitals and access of local people to the provisioning services of the Sundarbans Mangrove Forest, Bangladesh

Abstract

This study aims to understand the influence of livelihood capitals on access to Provisioning Services (PS) of the Sundarbans Mangrove Forest (SMF) including honey, crabs, mixed fish, shrimp, shrimp fry and fuelwood. The interactions among education level of eldest son, education level of eldest daughter physical weakness, total family member, mobile phone and TV possession, and number of boat shrimp farm size, total family land size, pirates permit, wage income and number of chicken livelihood group membership, co-op membership, number of close member, trust, solidarity and social cohesion played significant roles in shaping the composite effect of respective livelihood capitals on the access to PS. The effect of human capitals was significantly positive on people's access to fuelwood, shrimp fry and crabs consecutively; and negative on the access to honey, shrimp and mixed fish respectively. Physical capital was likely to increase access to shrimp, shrimp fry and crabs; and decrease access to fuelwood and honey respectively. Natural capital (land area) significantly increased the access to shrimp fry and shrimp; and reduced access to honey consecutively. Financial capitals had played significant positive roles in access to crabs, fuelwood and honey; and negative role in accessing mixed fish respectively. Social capitals was likely to enhance access to honey and fuelwood; obstructed access to crabs, shrimp fry and shrimp consecutively. Protection of any ecosystem from over exploitation and improved wellbeing of the

dependent communities can be achieved by addressing the influence of the livelihood capitals through the integrated development approach.

5.1 Introduction

Access, broadly defined as the ability to benefit from material objects, persons, institutions and symbols, is a prerequisite to enjoying the benefits of any resource. It is complicated by the political economic aspect of the concept which evidently divides the access mechanism into 'access control' and 'access maintenance'. The issue of control refers to function or power of directing and regulating who can access a resource (Rangan, 1997). Maintenance of access is another issue that requires expending resources or powers to keep a particular sort of resource access open (Berry, 1989). Smith *et al.* (2013) described this as the opportunity to benefit from Ecosystem Services (ESS) and to maintain this benefit for future generations to attain a sustainable society. One important types of ESS is Provisioning services (PS) which are the material benefits (e.g. food, medicines, raw materials, fresh water etc.) supplied by the ecosystem. The mechanisms of gaining access to PS vary between people depending on their available livelihood capitals (Ribot and Peluso, 2003). Livelihood capitals, which include natural, human, financial, physical and social capital (Fisher *et al.*, 2014, Costanza *et al.*, 2014) (Table 5.1) and are likely always interacting to influence how and when resources are accessed. For example, Bhandari (2013) reports that the size of cultivated land and livestock ownership significantly influence the livelihood activities of forest dependent people. However, elsewhere it has been stated that the availability of working age children and men also have a significant impact on livelihood strategies (Rakodi, 1999, Kibria *et al.*, 2014). Any opportunity of income other than ESS extraction is likely to reduce the ecosystem destruction (Wunder, 2001).

Adequate access to forest resources would ensure greater community wellbeing and ecosystem conservation because forest dependent communities are mostly marginalized with little to no opportunities for alternative livelihoods (Vedeld *et al.*, 2007, Naidu, 2011, Angelsen *et al.*, 2014). While one way to assess the level of access (or ability to benefit) is by the income generated from a resource (Ribot and Peluso, 2003, Ribot, 1998), this notion of access to resources has not been adequately addressed as past studies often use 'property rights' to measure access rather than focusing on other ways people may access resources. As such, by defining access as the 'ability to benefit' from any resources of the forest we can inevitably draw attention to a wider range of material, economic and social elements that are gained from resources without solely focusing on property rights (Ribot and Peluso, 2003). While some research has examined the factors that lead to decisions about livelihoods of ecosystem dependent people, expanding this to consider livelihood capital as a means to understand a household's decision on livelihood strategy is a relatively new development. In fact, to my knowledge, there has been no study that has explained the composite effect of livelihood capitals in the decision making of households in terms of which ecosystem resources they will extract from a forest ecosystem (Cinner *et al.*, 2009, Bhandari, 2013, Liu and Liu, 2016, Hua *et al.*, 2017). This leaves a considerable knowledge gap in our wider understanding of the complex interactions of livelihood capitals. Revealing these interactions will benefit policy makers and development organizations to better controlling access of the local people to the ecosystem by manipulating livelihood capitals instead of imposing harsher regulation and thereby ensure sustainable conservation of the ecosystems.

The Sundarbans Mangrove Forest (SMF) is relied on by over 3.5 million people from surrounding areas for their livelihoods, making the reduction of forest coverage (0.04% per year) quite alarming (Iftekhar and Islam, 2004a, Abdullah *et al.*, 2016). Growing population pressure, corruption and climate change have posed great threats to the

integrity of the unique mangrove ecosystem (Roy *et al.*, 2013). Miah *et al.* (2010) reported that over-exploitation is the most eminent threat to the biodiversity of SMF. As local villagers rely on the forest for PS to maintain their wellbeing, any reduction in access to these resources and services would put them under threat. In addition, competition for particular PS may jeopardize the integrity of the ecosystem and create challenges for sustainable management. This may be particularly true for resources for which there is a lack of control leading to unsustainable harvesting and large-scale biodiversity loss. Such loss weakens traditional conservation values and diminishes the effectiveness of local institutions (Stewart, 2003). To better mitigate this loss and understand its true impact, it is crucial to recognise the underlying reasons behind the harvesting of certain PS and acknowledge the complex interactions among livelihood capitals of individuals (Costanza *et al.*, 2014).

Table 5.1: Different types of livelihood capitals and their components.

Capitals	Definitions
Natural capital	Water, land, forests, air, hydrological cycle, pollution sinks etc. from which resources are generated and people can draw on their livelihood need.
Financial capital	These are vital to build confidence in pursuing any livelihood strategy include cash, credit/debt, savings, basic infrastructure and production equipment and technologies.
Human capital	The skill, knowledge, good physical and mental health, number working age member etc.
Physical capital	The basic infrastructure and the production equipment and technologies which enable people to derive benefits from any source.
Social capital	This includes trust and solidarity, networks and connectivity, social cohesion etc. This kind of capital ensures coordination and cooperation for mutual benefits.

Source: (Putnam *et al.*, 1993, Scoones, 1998, Nath and Inoue, 2009).

Given that the ability to benefit from PS is something which is determined by a range of livelihood capitals, the aim of this research is to investigate the relationship between livelihood capitals and access to PS of the villagers living around the SMF in Bangladesh. As the status of livelihood capitals of people determines their ability to consume any PS, understanding the interaction between the livelihood capitals and access to PS of these ecosystem dependent societies is key to achieving sustainability in natural resource management.

5.2 Methodology

5.2.1 Study area

Shyamnagar upazila was chosen as my study area based on its geographic location. The upazila is situated just beside the SMF and amongst a network of tidal rivers (Grant *et al.*, 2015) located between 21°36' and 22°24' N and 89°00' and 89°19' E (Figure 5.1). It is bordered by Kaliganj and Assasuni upazilas on the north, and the West Bengal state of India and the Bay of Bengal on the south. The average literacy of the area is 39.69% (male 47.75%, female 31.33%) and the majority of families live in extreme poverty. Villages along the coastal lines are very vulnerable due to frequent natural calamities in the monsoon season (Tamason *et al.*, 2016, Islam, 2003). A major part of the SMF belongs to this upazila; hence, the forest is the only source of livelihood of many of the villagers in the vicinity of the SMF.

The SMF is situated in southwestern Bangladesh, located between 21°30' and 22°30' N and 89°00' and 89°55' E extending over Khulna, Satkhira and Bagerhat districts (Figure 5.1). The SMF in Bangladesh forms the single largest contiguous mangrove forest in the world and is a unique national asset to Bangladesh in terms of its economic importance (Salam *et al.*, 2000). Its unique physical and physico-chemical environment has nurtured the growth of the most biodiverse mangrove in the world (Choudhury, 2001). Hence, the

forest is of enormous importance ecologically and economically at local, national and global scales. In fact, it has been recognised for having such value that UNESCO declared the forest a World Heritage Site in 1999 (Hoq, 2007). It covers an area of 6017 km^2 among which the total land area is 4143km^2 (includes exposed sandbars-42km^2) with the remaining 1874km^2 area including rivers, canals and small streams (Wahid *et al.*, 2007, Iftekhar and Islam, 2004b). The biodiversity of fauna and flora in the region is much higher than other large mangrove ecosystems (Wahid *et al.*, 2007). The Sundarbans reserve forest offers a diverse resource base for local people by supplying Provisioning Services (PS) including: honey, fish, crabs, nypa leaf, fuel wood and timber (Abdullah *et al.*, 2016).

This area is managed by four administrative ranges including, Sarankhola, Chandpain, Khulna and Satkhira. The whole SMF is divided into 55 compartments and it is under the control of Sundarbans Forest Circle. Commercial logging from SMF is banned (International Resources Group, 2010) and three wildlife sanctuaries facing the Bay of Bengal, were established in 1977 (Seidenstlcker and Hai, 1983). This valuable forest ecosystem, however, is currently experiencing numerous threats including illegal timber extraction, poaching of wildlife, sea-level rise, upstream water extraction/divergence, over fishing and harvesting of aquatic resources, plant disease, and river pollution (Aziz *et al.*, 2013, Mohsanin *et al.*, 2013, Roy *et al.*, 2013).

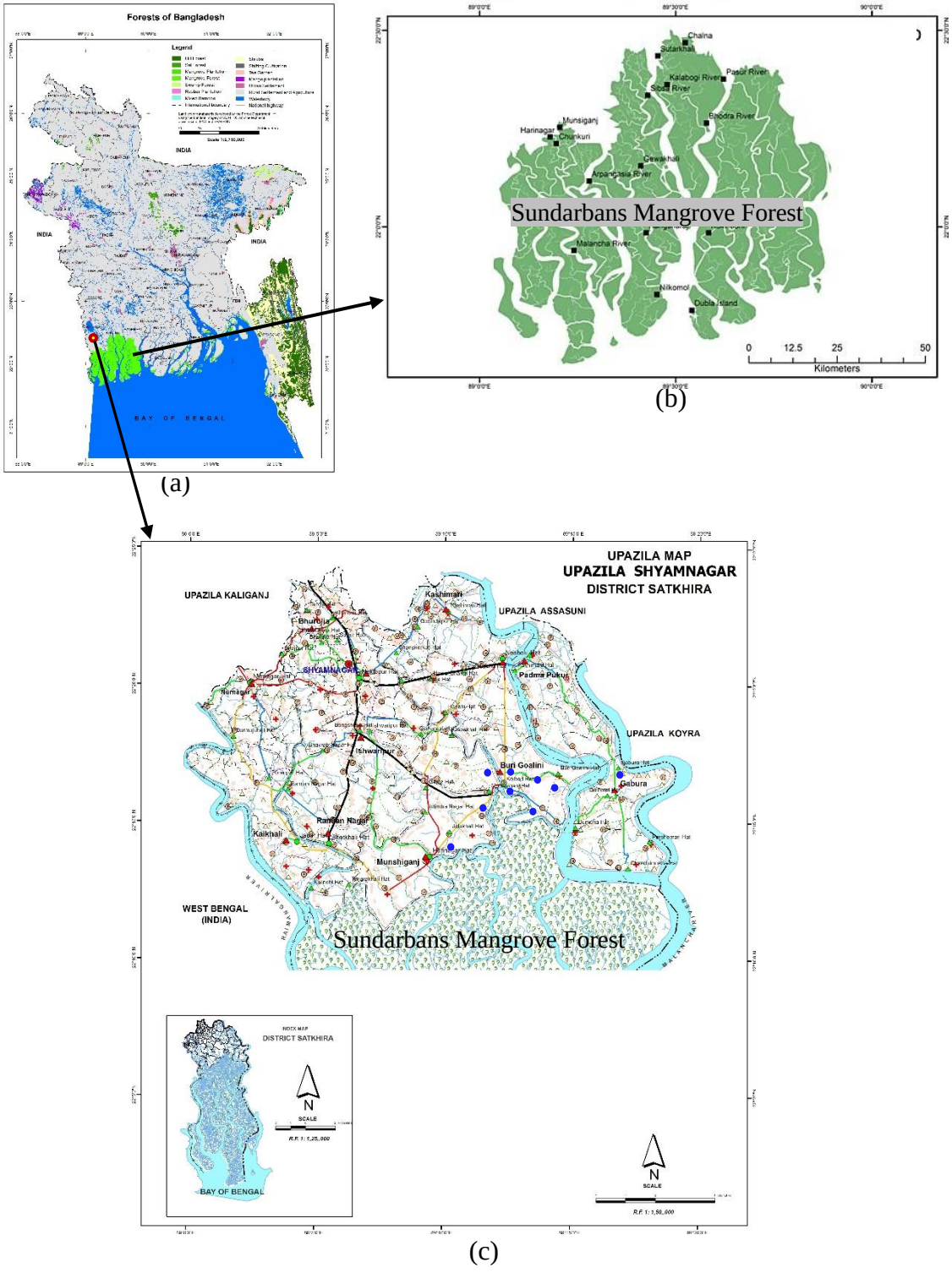


Figure 5.1: Map of : a) the forest zones of Bangladesh (Forest Department, 2017), b) the Sundarbans Mangrove Forest (Hossain *et al.*, 2015), c) Shyamnagar upazila of Satkhira district marked with the study villages in blue dots (Local Government Engineering Department, 2017).

5.2.2 Sample design and data collection

My sample households were drawn from the villages of Moukhali (N=10), Burigoalini (N=10), Gabura (N=10), Kalbari (N=15), Purbo Kalinagar (N=10), Kadamtali (N=10), Harinagar (N=13), Datinakhali (14) and Dhankhali (N= 12), which are situated in the Satkhira district. A complete list of villages in the area was obtained from a local NGO office (Centre for Natural Resource Studies or CNRS, Bangladesh) and from that list Irandomly selected a total of 104 households. The head of each selected household was interviewed using an face-to-face interview. The interviewees were predominantly male (100 men and four women) because women were generally not engaged in collecting PS from the forest, rather they stayed at home to take care of the family. In some cases (e.g. Crab collection, fuel wood collection) women may accompany men, thus while interviewing men about this, the views of women were also often noted. One widow was part of my initial sample, but as her eldest son was the primary PS collector they were both interviewed. For consistency, the same interview method was used to interview all household heads regardless of their locality and gender.

In each village I also conducted a focus group discussion, and interviewed key informants and elderly people by using open ended questions in order to explore background information on PS collection including the collection process, marketing, benefit sharing and challenges in each village that included members of all PS collecting groups. The whole process from ‘collection permission’ to ‘consumption’ was extensively discussed in each session. Key informants were selected based on their knowledge on the study subject and familiarity with local people. Additional qualitative and/or quantitative data also were collected by asking additional questions about interesting issues that emerged from the original interviews. People were asked to identify the capitals influencing a particular PS. At the beginning of every group discussion session, respondents were

adequately briefed about the livelihood capitals and influences on collecting PS.. People were asked to select influencing components from each livelihood capital type for each PS they collected (Table 5.1). Livelihood capital variables were then selected based on the consensus among group members which were the most important for the collection of the six identified PS. These were also checked during individual household interviews. Two social capital variables in the regression models (trust, togetherness) were also identified based on direct observations during field visits and interviewing with households. The lead author facilitated the selection of livelihood factors and finally categorized the factors under different livelihood capitals (Table 5.1). Seven visits were also arranged to observe PS collection activities and explore the factors influencing their collection.

I identified six types of PS that were collected by households from group discussions and key informant interviews. These included: honey, crab, shrimp fry, shrimp, mixed fish and fuelwood. Although nypa leaf is one of the major PS harvested from the Sundarbans forest elsewhere (Uddin *et al.*, 2013), I did not analyse it here as only a few villagers engaged in nypa leaf collection in my study. In collecting data on income from a particular PS of a household I considered income from both sold and consumed items.

5.2.3 Data analysis

To determine the level of access to PS in the SMF the gross average annual income of the households was calculated for each PS. The income from PS includes the income from both self-consumption and sold items. Rather than focusing on just one PS, each family engaged in collecting several types of PS, hence, trade-offs had to be made among the PS collections. A Pearson Correlation Matrix was developed to understand these trade-offs. As my study defined access gain as both ‘access control’ and ‘access maintenance’, the way each livelihood capital influenced different mechanisms of gaining access was

observed using both qualitative and quantitative data. After exploring the influence of livelihood capitals I also identified the influence of specific components of livelihood capitals on the level of access to PS in the SMF. OLS regression analysis was then performed to explore the effects of these livelihood capitals on the level of access to each individual PS. The models were prepared according the following equation (Eq. 1) (Dranove, 2012):

$$Y = \beta_0 + \beta_1 \chi_{i1} + \beta_2 \chi_{i2} + \beta_3 \chi_{i3} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + \beta_n \chi_{in} + \varepsilon_i \quad (1)$$

Here, Y= ability to benefit from a PS; β_0= intercept of the regression equation; $\beta_1, \beta_2, \beta_3 \ldots\ldots \beta_n$= regression co-efficient; and $X_1, X_2, X_3 \ldots\ldots\ldots\ldots X_n$ = independent variables; ε = the regression residual; i=1,2,3,……n.

A Variation Inflation Factor (VIF) identified multi-collinearity among the independent variables. As it is acceptable for VIPS values to be <5 (Craney and Surles, 2002, Slinker and Glantz, 1985, Vu *et al.,* 2015, Rogerson, 2001), I removed some of the violating predictors from the model until each of the VIF values were very low at <2.75). . To combine the effects of each respective dependent variables of each livelihood capital on the outcome variable, a single composite effect size was measured. The composite effect measurement is made up of the effect size of two or more variables which are related to one another. Thus, a composite effect is an estimate based on the multiple effect sizes found using descriptive statistics. The individual effects of the variables making up a composite variable may be single, scales, global ratings or categorical values (Song *et al.*, 2013, Gunter, 2015). One of the most precise methods for computing the 'composite effect size' of a set of predictor variables on an outcome variables comes from a single regression model that uses an arithmetic mean of standardized regression coefficients (Eq. 2) (Hedges and Olkin, 2014, Gunter, 2015, Song *et al.*, 2013).

$$Composite\ effect = \frac{\sum_{i=1}^{N} b_i}{N} \quad (2)$$

Here, b_i= standardized co-efficient value of i^{th} variable, N= number of significant variables of the respective capital.

5.3 Results

5.3.1 Level of access and trade-offs

Average annual income from PS received by the collectors was measured to understand the 'ability to benefit' or 'level of access' to each PS. The highest level of participation was observed in crab catching with a wider profit margin followed by shrimp fry, mixed fish, shrimp, honey and fuelwood. Generally, the annual profit from crab catching lies within US$255, which accounts for 54% of the people engaged in crab collection. The majority of households (75%) received up to US255yr^{-1}$ from mixed fish collection. The income from shrimp fry collection was below or equivalent to US255yr^{-1}$ which accounts for 75% of total families. Households (84%) who were engaged in shrimp catching generally made up to US255yr^{-1}$. The income from honey averaged US255yr^{-1}collector^{-1}$ which was received by 90% of the villagers. Fuelwood was collected for household consumption only; hence the money saved by the fuelwood was up to US255yr^{-1}$. It was observed that across the village earning over US$765 from a PS was very rare (Table 5.2).

Each household collects more than one type of PS; hence, there are always trade-offs among PS collections. I only found one slightly significant correlation between PS with shrimp fry and fuel wood. People collected shrimp fry in the river along the forest and they also collected fuelwood from the edge of the forest. These two activities were the least risky livelihood activities because pirates were mostly active deep inside the forest.

Villagers reported that the presence of pirate groups was a key decisive factor in trade-off decisions between accesses to different PS (Table 5.3).

Table 5.2: Household percentage involved in collecting different PS of the Sundarbans Mangrove Forest.

Collectability (US$ yr^{-1})	% of households engaged in collection of each PS					
	Honey	Crabs	Fuel	Shrimp fry	Shrimp	Mixed fish
0-255	89.9	53.9	100	75.2	83.9	75.0
255-510	8.7	22.1	-	9.9	9.8	15.4
510-765	-	18.3	-	11.1	5.2	3.8
765-1020	1	3.8	-	1.5	1.1	3.8
1020-1275	-	1	-	-	-	1.9
>1275	-	1	-	2.3	-	-

Table 5.3: Correlation between the access levels to the different PS of the Sundarbans Mangrove Forest identified as important based on interviews with nine local villages.

Name	Pearson correlation (r)					
	Crabs	Honey	Shrimp	Mixed fish	Fuelwood	Shrimp fry
Crabs	1					
Honey	.080	1				
Shrimp	-.116	.274	1			
Mixed fish	-.285	-.352	-.359	1		
Fuelwood	.056	.025	-.114	.040	1	
Shrimp fry	.026	.110	.001	.429	.351*	1

Note: * denotes correlation significant at the 0.05 level (2-tailed).

5.3.2 Access mechanism: control and maintenance

Figure 5.2 represents the access mechanism of the stakeholders to the PS of the SMF. Gaining access (control and maintenance) required people to use their human, natural financial, physical and social capital. Villagers, merchants, pirates, forest department (FD), police, rapid action battalion (RAB), and the coast guard were involved in access

control and maintenance to forest resources. The FD falls under the Ministry of Environment and Forest, while police, RAB and coast guard are controlled by the Ministry of Home Affairs. The police were primarily responsible for dealing with the confiscated person/s by the FD officials. The coast guard patrols along the coast line to stop any illegal activities while RAB occasionally runs operation for capturing the forest-pirates hiding inside the forest.

Administratively the FD is responsible to manage the forest. Villagers had to buy a permit from the FD to collect any resources, which cost US$3.2/week/person. Without this permit people were not able to legally collect any resource or even enter the forest. In reality, however, many people sneaked into the forest without permits to avoid paying the fees. If they were caught by FD officials, most of them admitted to paying a small bribe to escape. Forest pirates also illegally sold permits to collectors, which was reported to occur because pirates bribed the local police station to continue their activities. Villagers were always dependent on the local merchants for money and physical objects including boats, nets, drums etc. After collecting PS they would either sell to the merchants or share benefits with them based on their agreement. Merchants would then sell to urban traders who would eventually sell to customers elsewhere in the country. Some products such as shrimp and crab were also exported to the international market.

PS collecting groups also had to buy a permit from a pirate group to secure their collection (Figure 5.3); hence, their browsing range remained limited within the respective group's territory. However, they were also sometimes caught by another group from who they did not buy the permit and had to pay a ransom of US$130-380 to the pirates with the exact amount often depending on the appearance of the hostage (i.e. if he looks economically solvent, then they demand the maximum). Inside the forest, pirates maintain their territories by fighting each other. It was reported by the villagers that to

safeguard themselves pirates also killed some endangered Royal Bengal Tiger (*Panthera tigris*) and other wildlife including marsh crocodile and various types of snakes. Local people informed that they (pirates) earned huge money by selling those animals or their body parts in the black market.

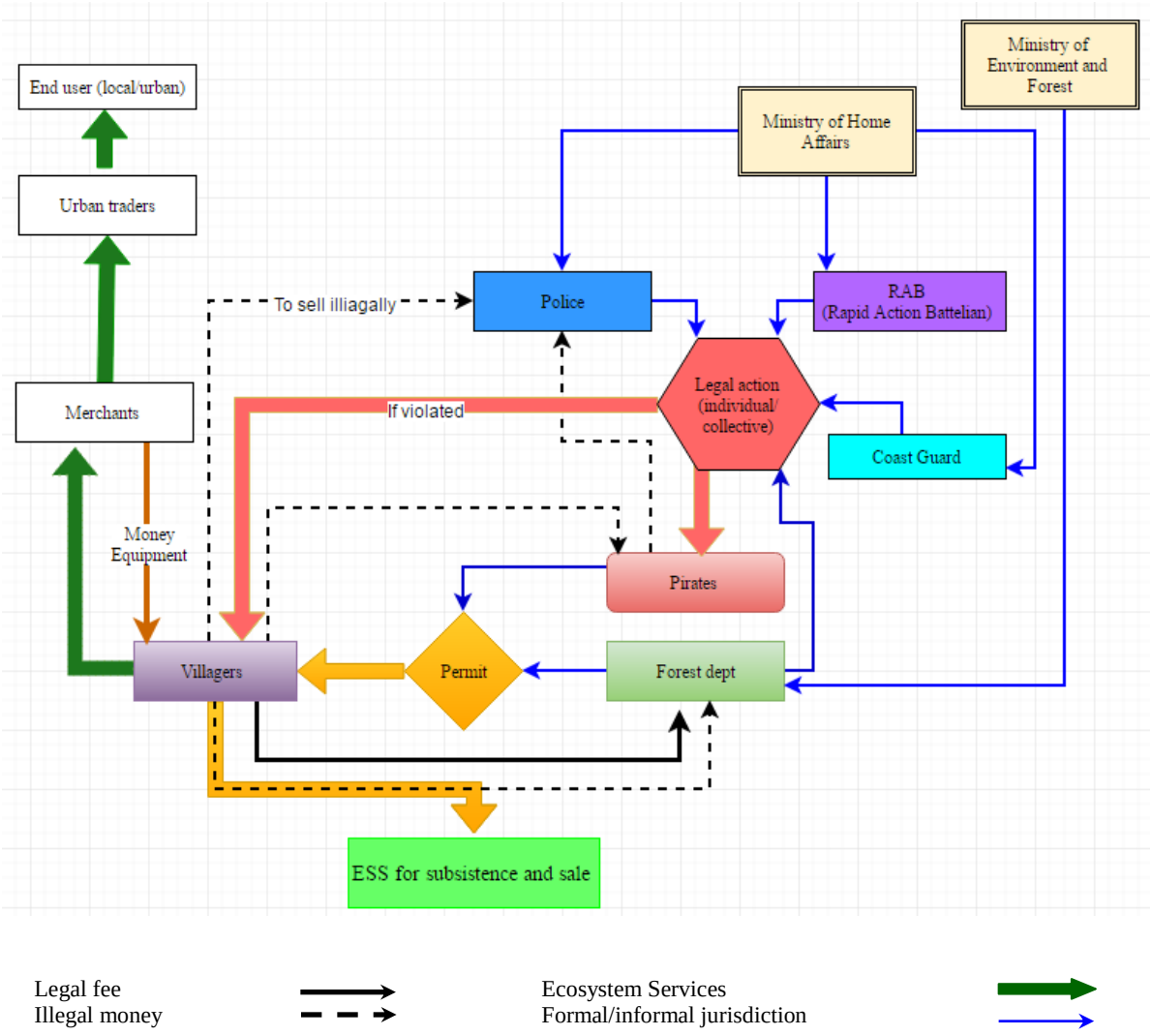


Figure 5.2: Access mechanisms and flow of capital among different stakeholders.

Access to most of the PS requires the formation of collecting groups i.e. people employ their livelihood capitals to gain access to the PS. The collection of honey, for example, requires a group of about 10 people along with a variety of tools (Figure 5.4). Collecting crabs did not always require relying on merchants; small scale collection was generally performed by two members of a family and required little capital investment, but large

scale extraction requires more capital and a group of 4-5 persons. There were two different types of shrimp fries captured locally called ‘Chati renu’ (*Macrobrachium rosenbergii*) and ‘Bagda pona’ (*Penaeus monodon*). People could catch them without any restriction as these were available in the river outside the forest. Mixed fish were obtained in the deeper part of rivers or the river-ocean meeting area, which took 7-8 days by boat to reach. Fishing required large boat and big nets; hence the members who had boat or net always played an important role while forming the group. Different merchant groups were active for different products and they were the main source of financial capital. Wholesalers or wealthy people provided loans either on interest or on an inter-locking credit agreement. Although merchants were the wealthiest part of the society, they always had to behave well and keep promises with the collecting groups to attract them into taking loans. As there was no written agreement signed, everything depended on mutual trust.

(a) (b)

Figure 5.3 (a,b): A permit card of a pirate group purchased by a collector group.

Figure 5.4: A group of people going to collect honey inside the forest. They will live in this boat about a month.

5.3.3 Livelihood capitals and access to PS

5.3.3.1 Human capital

Education level of the eldest son had a significantly negative influence on access to honey. The eldest son of a family was culturally meant to take responsibility for the family expenses; as such families often sacrificed income from the forest to educate the eldest son for a better job, which thereby reduced the vulnerabilities of the family. Contrary to this, the education level of the eldest daughter had a significantly positive impact on access to honey (Table 5.4). As schooling daughters was costly than schooling sons, and because of the local tradition that a fair amount of money is required to arrange the wedding of a daughter, household heads often decided to rely on a more profitable PS like honey to secure the future of a daughter.

I found that physical weakness significantly reduced access to shrimp catch (Table 5.4). Catching shrimp was solely dependent on a period locally called ‘Gon’ which is a period of 3-5 days that occurs once in every 15 day interval during the full and new moon when

the spring tides increase the tidal heights. Widespread inundation during this lunar cycle enables collectors to harvest shrimp. It was mentioned that fishermen had to stay awake for long periods to catch shrimp, which requires a considerable amount of physical stamina. Here age was not a decisive factor because both old and young individuals showed weakness, not only due to age but also to lack of nutrition.

(a)

(b)

Figure 5.5 (a,b): Shrimp fry collection river along the Sundarbans Mangrove Forest by approximately hundred boats under the scorching sun.

Access to shrimp fry was significantly determined by the physical condition of the household head, and the education level of both the eldest daughter and son. The education level of the eldest son had a significantly negative influence but the eldest

daughter's education had a significantly positive influence. Physical weakness had a significant and negative role in shrimp fry collection because if a person has a high level of physical stamina he usually goes for more profitable options, which are often physically very demanding (Table 5.4). Shrimp fry collection did not require any formal permission (i.e. no fee) and occurs in the rivers outside the forest, hence was safe from pirates, so that this risk free and easily accessible PS was the major option for their wellbeing especially when other options were difficult or impossible.

5.3.3.2 Financial capital

Problems caused by pirates were identified as having the biggest negative impact on honey and mixed fish collection as people frequently had to pay a pirate group in advance or as, which could not be afforded by the majority of villagers. Honey collectors had to roam around the forest for at least 15 days and thereby very susceptible to get caught by the pirates. Income from wage labouring both significantly and positively influenced access to honey. During the lean season/period many people work as hired wage labourers, mostly in other parts of the country to harvesting crops. They could spend some of the money afterwards to collecting honey as it requires higher capital investment. Mixed fish were collected during the 'Gon' period at 15 day intervals. Fishermen were required to enter deep inside the forest for a good catch where they must face the pirates, thus there is a significant negative relationship between the pirate crisis and access to mixed fish in the SMF (i.e. if the severity of pirates is high, people become reluctant to catch fish) (Table 5.4). People mentioned that they sometimes get caught by more than one pirate group and provide ransom to each of them.

Pirates played a significantly positive role in crab collection. It was mentioned that if they had no money to pay the pirates, people would collect crab because this could be done

within 1-2km of the forest edge where pirate attacks could be avoided. Crab collection was also a less laborious job and required less time with as few as two people being needed to obtain crabs. This typically involved the household head going to the forest with either his wife or his son. An interesting relationship was found between the number of domestic chickens and fuelwood consumption. A woman had to stay in the house to rear the chickens, which allowed her to cook more food. Moreover, households who had domestic animals were better off and woman of those families spent more time at home and cooking (i.e. more fuel wood consumption) (Table 5.4).

5.3.3.3 Natural capital

Shrimp farm size had a significantly negative influence on access to honey. While those who had larger properties were engaged in farming of shrimp or crab or poultry and became less involved in risky and difficult activities like honey collection. Total land area played a significant positive role to get access to shrimp collection (Table 5.4). They mentioned that shrimp selling was familiar to them and they could easily market the catch.

5.3.3.4 Physical capital

Possessing a television played a significantly positive role in crab collection. The relationship between having a television and access to crabs may be because of the increased close connection among the households as a result of watching popular shows together. During this time they were likely to share information (e.g. location of crab, market price) with close family members about the high price of crabs. Conversely, mobile phone possession had a significantly negative role in crab collection. Mobile phones allowed people to keep in regular contact with other villagers, which also resulted in greater social cohesion and bigger groups which eventually allowed them to be

engaged in other PS collection instead of relying on crabs. Boat possession had significantly positive effect on the shrimp collection. Owning a boat played a significant positive role to get access to shrimp collection. The person who had a boat could exercise a greater control over the catch. Having such a boat is costly and, hence, those who had fish catching boats used to catch shrimp regularly (Table 5.4).

5.3.3.5 Social capital

The number of memberships in livelihood groups and having more close social networks increases opportunities to be part of larger groups who would be more proficient at profitable resource extraction; hence reduced the access to less profitable crabs. Moreover, memberships of multiple cooperatives accelerated group formation and increased their abilities to work in a team. Thus, higher the group membership would significantly reduce access to crab collection from the forest. If a person was a member of multiple cooperatives, he/she also significantly reduced access to shrimp. Level of trust in the society played a significantly positive role to get access to shrimp collection.

Fuel wood collection was negatively impacted by the helping attitudes of villagers possibly because they helped each other to be engaged in the groups of PS collection. On the other hand togetherness was found significantly increase access to the fuel wood. Some families had to borrow a boat from another family to get fuelwood, hence togetherness across the society tends to increase the level of access to fuel wood. This social relationship also assisted a household to be included in different livelihood groups, which led to increased fuelwood collection partly because when they entered into the forest for other PS they would take the opportunity to collect fuelwood (Table 5.4).

Table 5.4: Results of an OLS regression model showing the relationship between livelihood capitals and level of access to the PS of the Sundarbans Mangrove Forest.

Capitals	PS	Variables	Coefficients	Std. Error	*t*	*p*
Human						
	Honey	Physical weakness	-17.537	10.993	-1.595	0.118
		EL of son-1	-33.471	9.591	-3.490	0.001
		EL of daughter-1	33.813	13.457	2.513	0.016
	Shrimp	Physical weakness	-36.735	14.959	-2.456	0.016
		EL of Son-1	24.426	18.159	1.345	0.182
		EL of HH	-31.481	25.647	-1.227	0.223
	Shrimp fry	Physical weakness	-55.719	24.546	-2.27	0.028
		EL of son-1	-75.439	23.789	-3.171	0.003
		EL of daughter-1	100.858	30.872	3.267	0.002
	Mixed fish	Physical weakness	32.397	21.768	1.488	0.140
		Total family member	-47.217	25.29	-1.867	0.065
		EL of son-1	-31.292	23.103	-1.354	0.179
	Fuelwood	No. of female member	1.165	1.094	1.065	0.292
		Total family member	0.117	0.785	0.149	0.882
		EL of daughter-1	0.169	0.515	0.329	0.744
Financial	Honey	Pirate's permit	-30.991	15.26	-2.031	0.049
		Wage	0.013	0.005	2.584	0.013
	Crabs	Pirate's permit	121.326	40.957	2.962	0.005
	Mixed fish	Pirate's permit	-108.026	33.837	-3.193	0.002
	Fuelwood	No. of chicken	0.692	0.242	2.865	0.006
Natural	Honey	Size of shrimp farm	-0.945	0.408	-2.315	0.026
		Family land size	1.585	1.357	1.168	0.250
	Shrimp	Family land size	5.895	2.61	2.259	0.027
	Shrimp	Family land size	-2.169	2.978	-	0.470

Capitals	PS	Variables	Coefficients	Std. Error	*t*	*p*
	fry				0.728	
Physical	Honey	Mobile phone	-11.426	41.983	-0.272	0.787
	Crabs	Mobile phone	-240.162	112	-2.144	0.038
		TV	453.042	98.041	4.621	0.001
		No. of boat	-19.59	69.308	-0.283	0.779
	Shrimp	No. of boat	100.067	49.128	2.037	0.045
	Shrimp fry	No. of boat	36.995	62.043	0.596	0.554
	Fuelwood	TV	-5.357	2.004	-2.673	0.010
Social	Honey	No. of livelihood group membership	30.657	13.087	2.343	0.024
	Crabs	No. of co-op membership	-135.49	45.36	-2.987	0.005
		No of close member	-7.537	3.222	-2.339	0.025
	Shrimp	No. of co-op membership	-84.941	30.646	-2.772	0.007
		Neighbours mostly trusted	31.838	15.878	2.005	0.048
	Shrimp fry	Membership of livelihood group	55.497	32.165	1.725	0.091
	Mixed fish	Neighbours are trusted	-22.931	20.831	-1.101	0.274
	Fuelwood	No. of livelihood group membership	1.611	0.749	2.151	0.036
		No. of close member	-0.06	0.056	-1.078	0.286
		Villagers mostly help each other	-1.407	0.52	-2.707	0.009
		Togetherness	1.273	0.625	2.036	0.047

Note: EL- Education level. HH- Household head; Honey: (n=104, R^2=0.491, R^2_{adj}=0.367, F= 3.958, p= 0.001); Crabs: (n=104, R^2=0.575, R^2_{adj}=0.466, F= 5.270, p= 0.001); Shrimp: Note: (n=104, R^2= 0.215, R^2_{adj}= 0.148, F= 3.202, p= 0.005); Shrimp fry: (n=104, R^2=0.328, R^2_{adj}=0.239, F= 3.666, p=0.005); Mixed fish: (n=104, R^2=0.161, R^2_{adj}=0.111, F=3.234, p=0.010); Fuelwood: (n=104, R^2=0.432, R^2_{adj}=0.328, F=4.141, p=0.001).

5.3.3.6 Composite effect of capitals

Composite scores used in Figure 5.6 represent the average of the standardized coefficients of all the significant variables of the respective livelihood capital. Composite scores of effect size suggest that human capitals had a negative effect on most of the PS collection except crabs (0.051) and fuelwood (0.074). The highest negative effect was found in honey collection (-0.107) followed by shrimp (-0.077), mixed fish (-0.057) and shrimp fry (-0.057). Considering the overall effects it can be said that with an increase in human capital the PS extraction would likely to decrease. The effect of physical capital was found to be highly positive on shrimp collection (0.208) and highly negative on fuelwood collection (-0.331). The lowest negative effect of physical capital was found on honey collection and the lowest positive impact was on crab collection. Natural capital (land area) had a highly positive impact on the shrimp collection. The households who were engaged in in cultivating shrimp on their land and hence, was very familiar to the business. May be because of this reason, they went only to shrimp collection for the forest. They also collected honey but natural capital showed a negative effect on the honey collection. Therefore, higher natural capitals are likely to lead pressure on the shrimp resources but would reduce pressure on other PS.

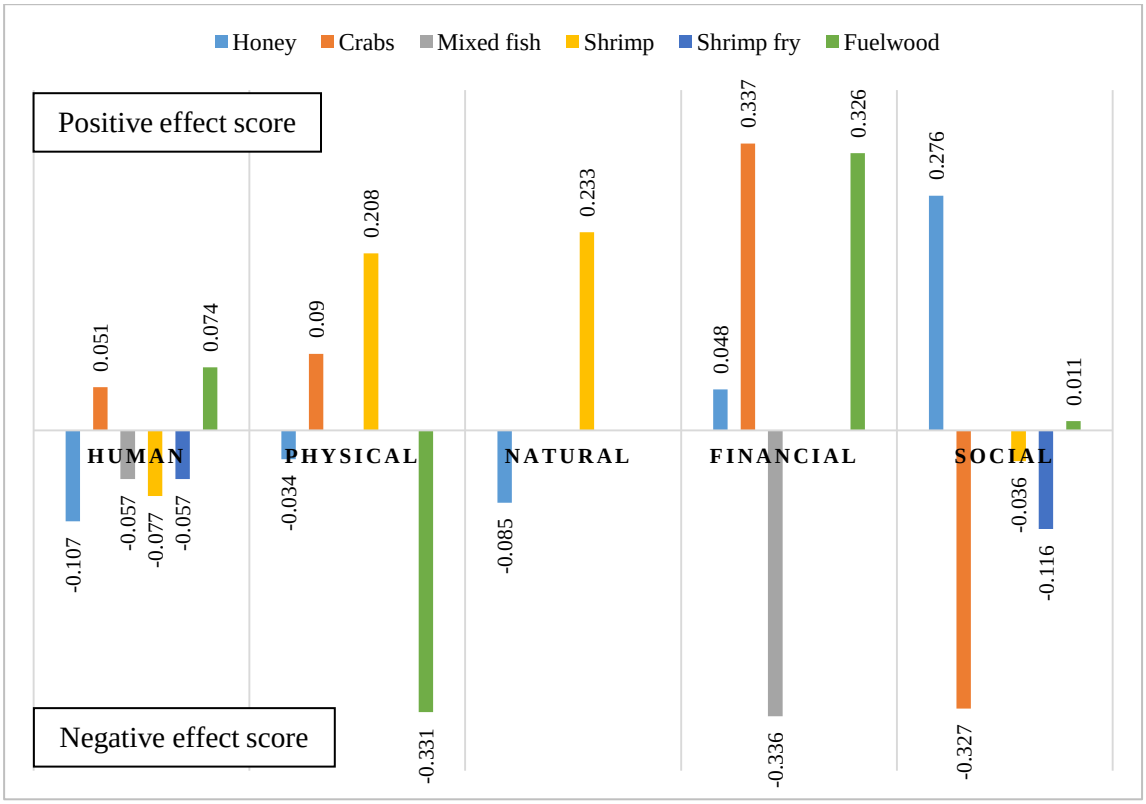


Figure 5.6: Composite effects (i.e. average value of standardized effect size) of livelihood capitals on the access to PS in Sundarbans Mangrove Forest.

Financial capitals had a strong positive impact on the collection of crabs (0.337) and fuelwood (0.326) collection. Crab collection was less risky and easier to collect then other PS. With the increase in financial capital the fuelwood collection was likely to increase may be because of their higher level of food consumption. There was a highly negative effect found on mixed fish collection. According to the collectors the most risky and physically intensive PS was mixed fish; hence, if they could manage money to invest for other resource collection, they would avoid to go for mixed fish. But it was interesting that honey collection was less strongly influenced by the change in financial capitals, although they mentioned that honey was profitable. This may be because honey was available only for three months of a year. Collectors who could manage higher financial capitals was engaged in more continuous income generating PS collection (Figure 5.6).

Social capital had a highly positive effect on honey collection. This is because to collect honey it required a group consists of 10-13 people. Without maintaining a higher social capital it was difficult to join the group. Social capital had a very strong negative effect on crab collection. Among all other capitals social capital had the highest impact on shrimp collection. But very low level of impact on fuelwood and shrimp collect was exerted by social capital (Figure 5.6).

5.4 Discussion

In the SMF, people gained access to the PS which were most easily available and had more risk free collection processes (e.g. shrimp fry). If they were able to take risk then access to the most profitable (e.g. mixed fish) was found the highest. The lowest access was observed in honey collection. Despite being one of the most popular PS of Sundarbans, the access level to honey was very low because of the high requirement of skills, manpower, financial support and the risk of getting attacked by pirates as well as tigers. Mitra (2000) also described that honey collectors have to observe the bee-movement and wind velocity in order to spot the possible location of honey bees. During collection of honey they also had to take precautions to avoid tiger attack and recent threat pirate attack (Inskip *et al.*, 2013, Barlow *et al.*, 2010). They also needed to arrange food to survive one month inside the forest for honey collection. Mixed fish was primarily collected on a small scale for people's own consumption and at a large scale to sell in the market. Capital requirements for small scale catching were lower as well as less risky. Shrimp fry collection was the least risky and capital intensive business because fry was available in the river around the forest and collecting from inside the forest was prohibited. Each household collected more than one type of ESS; hence, they always had to make trade-offs between PS. Such trade-offs are shaped by the livelihood capitals of the families. Individual components of livelihood capitals had varying effects on access

to PS. For instance, education level of the eldest daughter significantly led household heads to collect more honey and shrimp fry because schooling daughters was costlier than schooling sons. Moreover, families require a fair amount of money to arrange the wedding of daughters. In a group discussion in Kadamtali village a person reported that "*If the daughter does not have at least the basic education, she would suffer entire life. During marriage having primary education is also very important. On top of that, we need money for arranging wedding party and dowry. Although government discourages dowry, nowadays nobody agrees to marry without that.*" This statement was unanimously agreed by all the participants during the group discussion sessions and one-on-one interviews. Without creating safe and secured employment opportunities at the local level, female education apparently would drive people to more PS extraction which might lead to more environmental degradation. The primary intention of the families to educate their daughter was to marry her with an educated man promising a better career (Lichter *et al.*, 1995), as there were very few woman-friendly job opportunities. Contrary to this, an increase in the education of eldest son was likely to significantly reduce the PS extraction (i.e. the opposite effect of educating daughters).

With the exception of the above pattern, human capital generally had a negative effect on access to most of the PS. I found that access to honey, mixed fish, shrimp and shrimp fry were negatively influenced by household's human capitals. Only access to crabs and fuelwood were likely to increase with the increase in human capitals. Young men who acquired a basic education tended to move to the city for more lucrative jobs which eventually reduced the manpower to collect forest resources (Porter *et al.*, 2011). Non-farm income can remarkably reduce households' dependency on the forests and thereby accelerate forest ecosystem conservation (Kamanga *et al.*, 2009). Thus enhancing

education of man and by introducing more woman friendly employment or business opportunities would potentially reduce the dependency on the forest.

The effect of physical capital was found to have a highly positive effect on shrimp collection and negative effect on fuelwood collection. People who own boats are able to exercise a greater control over their catch. Having such a boat, however, was costly and, hence, those who had fish catching boats also used it to catch shrimp regularly – resulting in a positive relationship between the two PS. Physical capitals of the fishermen put them in a more secured position in the midst of already vulnerable livelihood of the coastal communities (Iwasaki *et al.*, 2009). Natural calamities often damage their boats and nets which are the most essential inputs for the fishermen to continue their livelihood (Islam *et al.*, 2014). Hence, maintaining these possessions requires a fair amount of financial capital. Thus, the poor always becomes reliant to the wealthy merchants who could afford the physical items (Barua *et al.*, 2012). Possessing higher physical capital (such as a television) had an influence on fuel wood collection, may be watching popular programs reduced the time available for fuel wood collection even though this was easily accessible and required the lowest capital investment. On the other hand, television possession had positive effect on the access to crabs possibly because of sharing information regarding crab availability and price trend when they gathered together to watch television.

Natural capital (such as ownership of land area) had a highly positive impact on the shrimp collection. This is because people who have land are able to cultivate shrimp on this property and hence, have higher levels of expertise with the shrimp selling mechanism. Cultivating shrimp is very profitable because of the agro-climatic conditions, abundant saline water, cheap labour force and growing demand in international market (Paul and Vogl, 2011, Deb, 1998). However, wild-caught shrimps were more expensive than cultivated ones in the market because naturally grown shrimps were reported to be

tastier and free from hormones and antibiotics. A similar result was found by Gruzen *et al.* (2006) in Madagascar suggesting that market value will always factor into decisions about shrimping. Because land ownership allowed households for the building of shrimp farms and to spend only 3-5 days in every fortnight collecting wild shrimp, while the rest of the time was spent on their own farms. Thus, there was a wide level of interest across the villages to collect shrimp for less time requirement in collection and greater market demand. Any opportunity of income other than PS extraction would likely to reduce the ecosystem destruction (Angelsen and Kaimowitz, 1999, Wunder, 2001). Shrimp farm size had a significantly negative influence on access to honey because owning a farm deterred them from risky and difficult activities like honey collection. Family land area and farm size significantly reduced access to PS as households employed their capital on the available land. Land size, either owned or rented, significantly and consistently influences the livelihood strategy of marginalized people around natural ecosystems (Babulo *et al.*, 2008, Santiphop *et al.*, 2011).

Financial capitals played the greatest role in PS extraction. Households with higher financial capitals were able to invest more, which resulted in larger income from PS extraction. This result was supported by Uberhuaga *et al.* (2012) who also argued that wealthier families were the primary harvester of the PS from the forests in lowland Bolivia. Financial capitals also had strong positive impacts on crabs and fuelwood collection. Crab collection was less risky and easier than other PS. With the increase in financial capital the fuelwood collection was also likely to greatly increase because of their higher level of food consumption. There was a highly negative effect found on mixed fish collection. According to the collectors the most risky and physically intensive PS was mixed fish; hence, if they could manage money to invest for other resource collection, they would avoid to go for mixed fish. Honey collection lasts only three

months (February to April) of the year and this is a non-perishable PS. In the rest of the year, especially during the PS extraction ban period (November-December), if there was any wage labour opportunity people would do that as a means to earn 'quick cash'. Godoy *et al.* (1997) also suggested that availability of wage labour income opportunities deflect away the economic effort of households from the forest. The severity of pirate attacks inside the forest made many villagers overwhelmed by debt and hence afraid of going inside the forest for PS, illustrated by one villager stating: "*If there was no pirate I could earn surplus without any outside-assistance. But now I am in huge debt after paying ransom two times in this year. I cannot manage proper meals these days and let alone other family expenses. I have no alternative other than going into Jungle (forest) but very much afraid if again get caught by them. My debt is already unbearable.*" Inskip *et al.* (2013) also reported that PS collectors in Sundarbans are trapped in a complex set of problems of which pirates attacks are one of the most severe ones.

Social capital generally impacted PS negatively, with the only exception being in honey collection. This is because of the requirement of a group consists of 10-13 people for collecting honey. Without maintaining a higher social capital it was difficult to join the group. Social capital had a very strong negative effect on crab collection. Higher level of social capitals opens up various employment opportunities to the villagers such as wage labour and migration in the urban areas (Rozelle *et al.*, 1999). As a result villagers with higher social capitals were engaged in only a particular profitable PS which might be the reason I found social capitals were likely to increase honey collection. Moreover, the social capital have shown effective in improving rural people's understanding of ecosystem and helping to develop new social rules, norms, and institutions for protecting the ecosystem (Mastrangelo *et al.*, 2014). This process of social learning helps new ideas which spread rapidly where there is high social capital, and thereby can lead to positive ecosystem outcomes (Pretty and Smith, 2004).

5.5 Conclusion

'Access' to PS or the 'ability to benefit' from PS are essential for maintaining the wellbeing of ecosystem-dependent communities. Components of each livelihood capitals may have different level of influence on the households to achieve access to the PS. With the increase in human capital people were likely to use the forest merely for the resources which had no better alternatives. Due to improved physical capitals collectors intensified their activities into the profitable PS. Natural capital had positively directed only to the resources that can be cultivated in household premises. But financial capitals increased the extraction of PS except which did not require higher investment of other capitals. Social capital had positive influence in deciding the resources where were collected larger groups and collection process was less capital intensive. Therefore, my study suggests that improving the human capitals and social capitals would be vital in changing the access to the PS and thereby ensure better conservation. For instance, the education level of the eldest son influenced access to honey and shrimp fry significantly and negatively. Therefore, access to PS is not granted; instead, it is achieved by using the range of livelihood capitals. In order to ensure proper access to the forest, the interactions of the livelihood capitals are required to be addressed. To protect a certain PS, the influence of the interactions leading to collect that particular PS should be controlled. Wider understanding of the access-livelihood capital nexus is extremely important for protecting any ecosystem from over exploitation and ensuring sustainable local wellbeing. To implement conservation projects these results would provide valuable guidelines. However, the research should be extensively replicated in order to determine the activities of the other villages around the SMF.

Chapter 6

Potentials of ecosystem services for improving human wellbeing of directly dependent communities

Abstract

This study presents the influence of Provisioning Services (PS) on human wellbeing including basic materials of life, health and sanitation, security, freedom of choice, and social relation in the Sundarbans Mangrove Forest (SMF). PS contributed significantly towards the availability and cleanliness of the non-drinking water. Food sufficiency was significantly decreased with the increase in the amount of ESS collection. Under the category of 'freedom of choice' PS is likely to significantly improve the capacity of the people to maintain social freedom, despite the significant increase in the level of obstruction to livelihood. A higher amount of PS extraction tends to significantly weaken the collectors physically. Mental health variables including self-esteem significantly decreased and anger level showed a significant increase with the increased amount of PS collection. Ability to secure some money in case of an emergency significantly increased due to a higher level of PS extraction. ESS collection is likely to increase social cohesion significantly by increased levels of ESS extraction. Composite wellbeing demonstrates that only physical health and economic security would significantly improve with the increase in ESS collection. My research suggests that sole dependency on the ESS from forest ecosystems, per se, is not enough to ensure greater wellbeing as well as sustainable conservation. Other development programs for water, food, health, education, and psychological and social improvement are essential to be incorporated to the conservation efforts.

6.1 Introduction

Ecosystem services (ESS) include the benefits generated from our surrounding ecosystems that are either directly enjoyed or consumed to improve human wellbeing (Daily *et al.*, 2009, Costanza *et al.*, 2014). Forests are one of the most important ecosystems as they support the life of billions of people at local and global scale (Byron and Arnold, 1999) through the provisioning of food, fresh water, shelter, environmental protection, recreation and education (MEA, 2003, Costanza *et al.*, 1997). While it is largely recognised that forest destruction results in a great loss of plants and wildlife, the impact that it has on human wellbeing has gone largely unrecognized (Davis *et al.*, 2015, Laurance, 1999), because a loss in ESS has not been identified as something which carries a negative consequence in this respect. The loss of pollinators associated with deforestation, however, has direct implications for agricultural production, through changes in people's ability to grow fruits, vegetables, oil crops and stimulants (e.g. coffee, tea). This would then have knock-on effects in terms of agriculture and farming. Despite this, a reduction in forest destruction is generally not considered as an important step to fighting the problems of losses in food production (Gallai *et al.*, 2009).

The Millennium Ecosystem Framework has attracted the attention of global ecosystem scientists to the relationship between ESS and human wellbeing. One major drawback of the current framework (Fisher *et al.*, 2014), however, is that it does consider the multidimensional nature (Narayan *et al.*, 2000) of the relationship composed of many facets including basic materials for good life, freedom and choice, health good social relations and security. The intricate nature of human wellbeing and its relation with the ecosystems restricted researchers to have a robust understanding on the vast topic (Kamanga *et al.*, 2009, Nowak *et al.*, 2006, Sunderlin *et al.*, 2005). Thus, more precise

analyses are needed to explore the relationship of ESS to human wellbeing in these complex terms (MEA, 2003).

The Sundarbans is the world's largest continuous mangrove ecosystem and a unique national asset to Bangladesh in terms of economic importance (Salam *et al.*, 2000). People living around the Sundarbans mangrove forest heavily rely on the ESS it provides, including honey, fish, crabs, nypa leaf, fuelwood and timber (Abdullah *et al.*, 2016). The forest is of enormous importance ecologically and economically at local, national and global scale, but at present this valuable forest ecosystem is under numerous threats such as illegal logging, poaching of wildlife, sea-level rise, upstream water extraction/divergence, overfishing and harvesting of aquatic resources, plant disease, and river pollution (Aziz *et al.*, 2013). As ESS are important for human wellbeing not only in a global context but particularly for the marginalized communities whose livelihoods are often directly dependent on ecosystems, the impact of these threats requires further investigation (Abraham *et al.*, 2010, Kalaba *et al.*, 2013).

Having an understanding of the complexities of the relationships between the forest and the people have thus far been limited to the economic dependency of the people on the forest ecosystem (Abdullah *et al.*, 2016, Adhikari *et al.*, 2004, Babulo *et al.*, 2008). Moreover, most of the studies focus on the economic contributions of ESS in terms of generating income, employment, and infrastructure (Adam *et al.*, 2013, Kibria and Jashimuddin, 2012, Kar and Jacobson, 2012) with little to no attention paid towards impacts on human wellbeing. This may be partially explained by the mainstream view of wellbeing still being heavily focused on narrowly defined economic growth (Blanchflower and Oswald, 2004, Stewart, 2005). Hence, there is a considerable research gap in understanding the effects of forests or forest management programs on households that rely on forests for other types of wellbeing including physical, mental, institutional

and social improvement (Narayan *et al.*, 2000, Costanza *et al.*, 2007, McElwee, 2008). This research aims to fill this gap by exploring the relationship between PS and human wellbeing in the Sundarbans forest ecosystem of Bangladesh by exploring how each PS impacts the wellbeing of the dependent communities.

Results of this study can be used to highlight the robustness of the relationship between this ecosystem and human wellbeing by illustrating the complex relationship that exists between PS and human wellbeing. This research will also assist new research initiatives devoted to attain sustainable development. As such, results will not only benefit policy makers and development organizations engaged in forest ecosystem conservation, it will also provide guidelines to achieve sustainable growth in other sectors including agriculture, industries, tourism, and mining.

6.2 Methods

6.2.1 Study site

The Sundarbans mangrove forest has such value that UNESCO declared the forest a World Heritage Site in 1999 spanning mainly over Bangladesh, and a part in India (Hoq, 2007, Roy *et al.*, 2013). The Sundarbans Mangrove Forest (SMF) is situated in southwestern Bangladesh located between 21°30' and 22°30' N and 89°00' and 89°55' E extending over Khulna, Satkhira and Bagerhat districts (Figure 6.1). The forest in Bangladesh forms the single largest contiguous mangrove forest in the world covering an area of 6017 km^2 (Iftekhar and Islam, 2004) made up of 4143km^2 (includes exposed sandbars: 42km^2) land area and 1874km^2 water area (including rivers, canals, and small streams). The biodiversity in the region is much higher than that found in other large mangrove ecosystems in the world (Wahid et al., 2007). Mangroves provide substantial PS for local communities. Ecosystem products, such as fish, honey, and nypa palm,

shrimp fry, fuel-wood, water are the only sources of income and subsistence for many of the marginalized people in the vicinity of Sundarbans (Getzner and Islam, 2013). Thus, over three million people are directly or indirectly dependent on the forest for their livelihood and survival (Roy *et al.*, 2013).

6.2.2 Sampling, data collection and analysis

A complete list of villages in the area was obtained from a local NGO office (Centre for Natural Resource Studies or CNRS, Bangladesh) and from that list I randomly selected the villages that I would visit for this study. From nine randomly selected villages: Moukhali (N=10), Burigoalini (N=10), Gabura (N=10), Kalbari (N=15), Purbo Kalinagar (N=10), Kadamtali (N=10), Harinagar (N=13), Datina khali (14) and Dhankhali (N= 12) around the Shatkhira Range of the SMF, a total of 104 households were visited and a total of 104 households were randomly selected. In each household, I interviewed the household head using interpersonal (i.e., face-to-face) communication methods with a pre-tested questionnaire. Sampled households were divided into two categories based on the income they earned from ESS: Lower access or LA (income<BDT70000 yr^{-1}= US$893 yr^{-1}) and Higher access or HA (income> BDT70000 yr^{-1}= US$893 yr^{-1}). In the LA category, there were 56 households while the HA category comprised 48 households. In each village, I also conducted a focus group discussion and interviewed key informants and elderly people. For consistency, the same interview methods were used to interview all household heads regardless of their locality and gender. The questionnaires were pre-tested to check the efficiency of the questions to collect desired data. In each village, I also conducted a focus group discussion and interviewed key informants and elderly people. Key informants were selected based on their knowledge of the subject under the study, and their familiarity with the local people and culture. Additional qualitative and/or quantitative data also were collected by asking additional questions about

interesting issues that emerged from the original interviews. Information regarding the socio-economic conditions of the collectors and challenges of PS collection were also obtained from the published reports of CNRS.

Based on the group discussions and key informant interviews, common PS collected by the villagers in that part of the forest were identified. Although nypa leaf is one of the major ESS harvested from Sundarbans forest (Uddin *et al.*, 2013), I did not consider this for my study, because only a few villagers were found engaged in nypa palm collection as wage labourers (i.e. the sample size was too small to analyse).

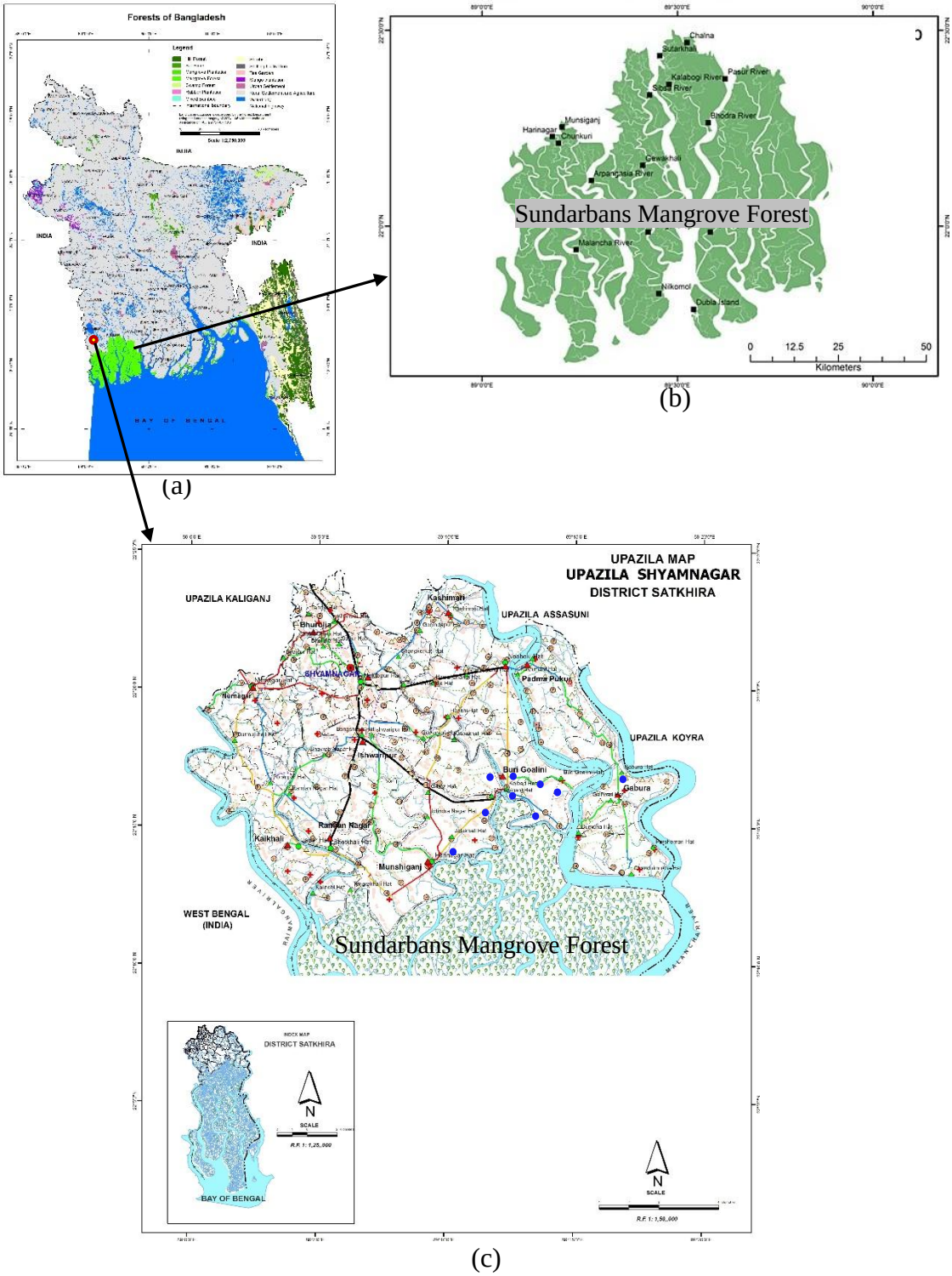


Figure 6.1: Map of : a) the forest zones of Bangladesh (Forest Department, 2017), b) the Sundarbans Mangrove Forest (Hossain *et al.*, 2015), c) Shyamnagar upazila of Satkhira district marked with the study villages in blue dots (Local Government Engineering Department, 2017).

I also collected data on four general wellbeing criteria (Fisher *et al.*, 2014, Narayan *et al.*, 2000, Costanza *et al.*, 2007, MEA, 2003) based on interviews and discussions with the groups. The effect of each of these criteria on human wellbeing was measured through the use of scores varying from small to large impacts (Table 6.1). These overall scores were calculated by adding up the individual scores from each of the respective indicators within each criterion. The differences between the two access groups- Lower Access (LA) and Higher Access (HA) were then tested using independent sample t-test by using SPSS. While conducting independent sample t-test the normality of the data was checked by generating histogram and normal probability plot.

Table 6.1: Variables of human wellbeing of the ecosystem services in the Sundarbans Mangrove Forest.

Wellbeing criteria	Determinants	Indicators and their scores	Scores
Basic materials of good life	Drinking water	a) Distance to water source	a) <0.5km= very high, 0.5km to1km=neither nor, >1m= very low
		b) Source of water	b) Village pond= Very low, Own pond = Neither nor, Common reserve tank = High, Supply water= Very high
		c) Amount	c) Sufficient: Very high wellbeing, Moderate amount= neither nor, Insufficient= Very low wellbeing.
		d) Period of availability	d) Whole year= Very high wellbeing, Seasonal scarcity= Neither nor, Irregular supply= Very low wellbeing
		e) Taste	e) Good= High wellbeing, Fair= Neither nor, Bad= Low wellbeing
		f) Cleanliness*	f) 1 to 5 scale where 1- very low wellbeing and 5- very high wellbeing]
		g) Health risks	g) High risk= Very low wellbeing, Minor= High wellbeing, Not at all= Very high wellbeing
	Water for other purpose	a) Distance of water source	a) <0.5km= Very high, 0.5km to1km=Neither nor, >1m= Very low
		b) Source of water	b) Sweet water pond= High wellbeing, River= Neither nor, Own pond= Very high wellbeing.
		c) Amount	c) Sufficient: Very high wellbeing

Wellbeing criteria	Determinants	Indicators and their scores	Scores
		d) Period of availability	d) Whole year= Very high wellbeing, Seasonal scarcity= Neither nor
		e) Cleanliness*	e) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
		f) Health risks	f) High risk= Very low wellbeing, Minor= High wellbeing, Not at all= Very high wellbeing
	Food availability	a) Purchased	a) Major amount= Very low wellbeing, Moderate amount= Neither nor, Little supplement= Very high wellbeing
		b) Chronic shortage	b) High= Low wellbeing, Moderate= Neither nor, Low= High wellbeing
		c) Sudden shortage	c) >3month= Very low wellbeing, 3months= Low wellbeing, 2 to <3months= Neither nor, 1 to 2months= High wellbeing, <1month= Very high wellbeing
Health	Good physical health	a) Physical weakness*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
		b) Frequency of disease per year of family members	b) >15, 10-15, 5-10, 3-5, 1-3
		c) Chronic diseases of family members	c) The more severe disease, the less wellbeing
	Good mental health	a) Happiness*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
		b) Self-esteem*	b) Codes are as (a)
		c) Stress*	c) Codes are as (a)
		d) Anger*	d) Codes are as (a)
Security	Personal security	How much security is for personal assets	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	Certainty of employment	How much certain is to conduct ESS extraction	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	Certainty of ESS availability	How much certain is to find and collect ESS	1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
	Difficulty with emergency money	Easiness to receive	The easier to get loan from a person/organization, the higher wellbeing
	Trust and solidarity relations	a) Most of the people can be trusted *	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
		b) How much public authority is trusted *	b) 1- not at all, 2- low, 3- moderate, 4- high wellbeing
		c) Most of the people are willing to non-financial	c) Codes are as (a)

Wellbeing criteria	Determinants	Indicators and their scores	Scores
		help*	
		d) Most of the people are willing to help financially *	d) Codes are as (a)
	Collective action and cooperation	a) How likely people work to protect ESS	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
		b) How often you attended community services	b) The more attendance, the more wellbeing
		c) How many people work in protecting forest	c) Everyone= Very high wellbeing, Nobody= Very low wellbeing
	Groups and network	a) No. of group membership	a) 0- Very low wellbeing, 1-Low wellbeing, 2- Neither nor, 3-High wellbeing, 4or more- Very high wellbeing
		b) No. of close friends/families	b) <5- Very low wellbeing, 5to <10- Low wellbeing, 10- Nether nor, >10to 15- High wellbeing, >15-Very high wellbeing
	Social cohesion	a) Togetherness*	a) 1 to 5 scale where 1- Very low wellbeing and 5- Very high wellbeing
		b) No. ceremonies attended per year	b) <3- Very low wellbeing, 3 to5- Low wellbeing, 5 to 10- Neither nor, 10 to 15- High wellbeing, >15- Very high wellbeing
Freedom of choice	Social Freedom	a) Free to do what is preferred*	a) 1 to 5 scale: 1- Very low wellbeing and 5- Very high wellbeing
		b) Villagers respect each other's preferences*	b) Codes are as (a)
		c) Other restrict him/her	c) Codes are as (a)
		d) Impartial justice exist	d) Yes= Very high wellbeing, No= Very low wellbeing]
		e) Ability to react to livelihood perceived threat	e) Failed to react= Very low wellbeing, Flee =Low, Apologise= Neither nor, Mutually solved/money= Very high wellbeing
		f) Able to achieve anything in anyway*	f) Codes are as (a)
	Economic freedom	Open market	Free market= Very high, Restricted market=Very low
	Institutional protection	Institutions defend	Him only, NGOs, Public office= low

Note: [a] data were collected on the scale of 1-strongly agree, 2-agree, 3- neither nor, 4-disagree, 5-strongly disagree. But for wellbeing the data were reversely coded i.e. 1→5 (very high wellbeing), 2→4 (high wellbeing), 3→3 (nether nor), 4→2 (low wellbeing), 5→1 (very low wellbeing).

6.3 Results

6.3.1 Resource access

Overall, I found a significant difference between the income gained from PS between LA (US$629yr^{-1}) and HA ($US1575yr^{-1}) households (t = -7.959; p = 0.001). This was primarily because of significant differences in the amount of honey (t = -2.445; p = 0.018) and crabs collection between the two groups (t = -3.873; p = 0.001). LA families made the highest income from shrimp fry (US$361yr^{-1}) followed by shrimp (US$355yr^{-1}), mixed fish (US$338yr^{-1}), crabs (US$310yr^{-1}), honey (US$68yr^{-1}) and fuelwood (US$156yr^{-1}). The highest income of HA families was from shrimp fry collection (US$693yr^{-1}) followed by crabs (US$556yr^{-1}), mixed fish (US$459yr^{-1}), shrimp (US$164 yr^{-1}), honey (US$130 yr^{-1}) and fuelwood (US$154 yr^{-1}). The highest number of LA households collected fuelwood (93%) followed by crabs (62.5%), honey (30%), mixed fish and shrimp (25%), and shrimp fry (18%). In the case of the HA families, the highest participation was also in the collection of fuelwood (98%) followed by crabs (94%), honey (67%), mixed fish (60%), shrimp fry (46%) and shrimp (37.5%) (Table 6.2).

Table 6.2: Resource access of both lower access (LA) and higher access (HA) households in the Sundarbans Mangrove Forest.

ESS	LA (US$ yr^{-1})	HA (US$ yr^{-1})	*t*	*p*
Honey	67.80 (30.40)	194.03 (66.70)	-2.445	.018
Shrimp	355.32 (25)	436.81 (37.50)	-.984	.333
Shrimp fry	360.90 (17.90)	693.18 (45.80)	-1.540	.136
Mixed fish	338.83 (25)	459.77 (60.40)	-1.162	.252
Crabs	309.52 (62.50)	556.41 (93.70)	-3.873	.001
Fuelwood	156.21 (92.90)	153.85 (97.90)	.221	.825
Total	629.44	1575.04	-7.959	.001

Note: Values in the parentheses are household percentages.

6.3.2 Basic materials of good life

I found PS collection significantly improved the availability of clean water used for non-drinking purposes for the whole year ($t = -2.007$; $p = 0.047$), which also significantly ($t = 2.007$; $p= 0.047$) reduced the seasonal shortage of water. Water cleanliness between these two user groups were also significantly different (strongly agree: $t = 2.423$; $p = 017$; disagree somewhat: $t = -2.044$; $p = 0.044$). Food sufficiency was significantly (agree somewhat: $t = 2.021$; $p = 0.041$) reduced due to increase in PS collection. PS had no significant effects on other elements of basic materials of good life including air quality, drinking water availability and safety, food purchasing power and chronic shortage. Villagers agreed that air quality in their areas was very high, although some people were concerned about the salt-laden air in the coastal area. On the contrary, managing fresh water was identified as the biggest challenge for the villagers. Almost half of the population received water from the common sweet water pond in the village, which had to be treated with 'alum' before drinking. More than half of the population use treated water from the supplied sources (LA: 27%, HA: 44%) and a common reserve water tank (LA: 25%, HA: 12%) installed by the NGOs. In general, villagers had sufficient fresh drinking water (LA: 93% and HA: 90% of the population) all the year round (LA: 89%, HA: 88% of the population) although some had to travel about a kilometre. The taste of drinking water was similar in two groups, varying from good (LA: 50%, HA: 44%) to fairly good taste (LA: 48%, HA: 54%). Regarding the cleanliness of water, a higher number of LA families (57%) agreed that their water was cleaner than HA households (52%). But serious dissatisfaction was observed to be higher across the LA group (12.5%) than the HA group (4.2%). There was a higher level of concern over water-borne diseases in LA households (7% reported high risk) than in HA families (zero percent), likely because they had access to treated water. There was a considerable difference

observed between the LA and HA families who considered the drinking water entirely safe (LA: 40%, HA: 54%). Despite the difference between the groups of villagers, there was no statistical significance found between them in regards to the drinking water (Table 6.3).

Figure 6.2: Common sweet water pond used by the villagers of Purba Kalinagar near the Sundarbans Mangrove Forest.

Water for other purposes (e.g. bathing, washing clothes and utensils, etc.) was available within less than half a kilometre (LA: 0.16km, HA: 0.21km). In most of the cases, sweet water ponds were also used for other purposes by both LA (87%) and HA (81%) families. Using river water for other purposes was higher among HA group (19%) compare to LA families (12.5%), as the HA households predominantly used supplied water for which they had to pay. Despite some seasonal scarcity, water for other purposes was available whole year from different sources (Table 6.3).

Because it is a mangrove ecosystem, the Sundarbans does not supply a lot of food materials. PS that are collected are primarily sold in the marketplace to buy other food items. Surprisingly, it was found that a few families in the LA group were less dependent on the market than HA families. This does not mean that the families were

having/producing sufficient food, but rather they were not able to purchase enough to meet their needs. All the families suffered from chronic food shortage to some degree, but due to having less money, more LA families suffered from chronic food shortage than HA families (Table 6.3).

Table 6.3: Comparison between the basic materials of life of lower and higher access groups around the Sundarbans Mangrove Forest.

Components	Lower access	Higher access	*t*	*p*
Air is clean (% of HH)	100	100	-	-
Water for drinking/cooking (% of HH)				
Distance from source of water (km)[d]	0.99	0.81	1.122	.265
Source of water				
Sweet water pond	46.4	43.8	.271	.787
Supply water	26.8	43.8	-1.824	.071
Common reserve tank	25.0	12.5	1.617	.109
Own sweet water pond	1.8	-	1.0	.322
Availability				
Sufficient	92.9	89.6	.580	.564
Moderately sufficient	-	-	-	-
Insufficient	7.1	10.4	-.580	.564
Whole year	89.3	87.5	.280	.780
Seasonal scarcity	5.4	2.1	.889	.376
Irregular supply	5.4	10.4	-.938	.351
Taste of water				
Good	50.0	43.8	.632	.529
Moderate	48.2	54.2	-.601	.549
Bad	1.8	2.1	-.108	.914
Cleanliness				
Agree strongly	30.4	25.0	.605	.546
Agree	26.8	27.1	-.034	.973

Components	Lower access	Higher access	*t*	*p*
somewhat				
Neither nor	16.1	20.8	-.617	.539
Disagree somewhat	14.3	22.9	-1.132	.260
Disagree strongly	12.5	4.2	-1.081	.282
Need to pay	-	-	-	-
Health risk of the water				
High	7.1	-	1.903	.060
Minor	53.6	45.8	.781	.436
Not at all	39.3	54.2	-1.517	.132
Don't know	-	-	-	-
Water for other purposes (% of HH)				
Distance from source of water (km)[d]	0.16	0.21	-.723	.472
Source of water				
Own sweet water pond	44.6	37.5	.734	.465
River	12.5	18.8	-.864	.390
Village pond	42.9	43.8	-.091	.928
Availability				
Sufficient	100	100	-	-
Moderately sufficient	-	-	-	-
Insufficient	-	-	-	-
Whole year	87.5	97.9	-2.007	.047
Seasonal scarcity	12.5	2.1	2.007	.047
Cleanliness				
Agree strongly	19.6	4.2	2.423	.017
Agree somewhat	17.9	10.4	1.072	.286
Neither nor	35.7	37.5	-.187	.852
Disagree somewhat	26.8	45.8	-2.044	.044
Disagree strongly	-	2.1	-1.081	.282
Health risk of the water				
Minor	57.1	52.1	.512	.610
Not at all	35.7	41.7	-.616	.539
Don't know	7.1	6.3	.180	.857

Components	Lower access	Higher access	*t*	*p*
Food (% of HH)				
Food is enough to feed family				
Agree strongly	1.8	4.2	-.697	.488
Agree somewhat	28.6	12.5	2.021	.041
Neither nor	33.9	43.8	-1.018	.311
Disagree somewhat	23.2	31.3	-.961	.362
Disagree strongly	12.5	8.3	.693	.490
Purchasing food				
Major amount	92.9	89.6	.580	.564
Moderate amount	5.4	10.4	-.960	.339
Little supplement	1.8	-	1.000	.322
Chronic food shortage				
Moderate	25.0	22.9	-.390	.697
Low	48.2	52.1	.246	.806
High	26.8	25.0	.205	.838
Sudden shortage for how long (months)	2.80	2.48	.808	.421

6.3.3 Freedom of choice

It was found that significantly more HA households (agree strongly) (64%) felt that they faced a higher level of restriction from fellow villagers when compared to LA group (59%) ($t = -2.497$; $p = 0.014$). A significantly greater number of HA families (83%) did not face issues with money as they were better off than LA households (64%) ($t = -2.213$; $p = 0.029$). They were also significantly more capable (52%) than LA families (32%) to mutually solve an issue that was posing a threat to their livelihood ($t = -2.082$; $p = 0.040$). As a result, a significantly ($t = 2.423$; $p = 0.017$) higher number of LA families (20%) sacrificed their interests because of their inability.

People's freedom of choice was heavily restrained by pirates in the forest. It was unanimously agreed that pirates posed the greatest threats to them. There were several groups of pirates active inside the forest. Their group size varies from 5-50 members mainly from outside their localities. Villagers mentioned that few undercover informers

were from their locality. They also mentioned that pirates are from ultra-poor people, often people who had lost everything in a natural disaster including floods and river erosion.

Table 6.4: Comparing freedom of choice between higher and lower access groups around the Sundarbans Mangrove Forest.

Components	% of household		*t*	*p*
	Lower access	Higher access		
Institutions for freedom of choice				
Organization/person to defend right				
Him only	96.4	97.9	-.457	.649
NGOs	3.6	2.1	-.108	.914
Government authorities	1.8	-	1.000	.322
Impartial judiciary exists	100	100	-	-
Organization to restrain the right				
Pirates	100	100	.586	.559
NGO	16.4	18.7	-.622	.536
Government authorities	8.9	10.4	-1.142	.256
Social freedom				
Free to do what is preferred				
Agree strongly	14.3	16.7	-.331	.742
Agree somewhat	16.1	12.5	.517	.607
Neither nor	8.9	16.7	-1.186	.238
Disagree somewhat	19.6	20.8	-.149	.882
Disagree strongly	41.1	33.3	.810	.420
Members respect each other's preferences				
Agree strongly	33.9	37.5	-.375	.708
Agree somewhat	17.9	20.8	-.379	.706
Neither nor	23.2	27.1	-.448	.655
Disagree somewhat	14.3	8.3	.959	.340
Disagree strongly	10.7	6.3	.817	.416
Others restrict my livelihood				
Agree strongly	19.6	41.7	-2.497	.014
Agree somewhat	39.3	22.9	1.799	.075
Neither nor	14.3	16.7	-.331	.742
Disagree somewhat	17.9	12.5	.758	.450
Disagree strongly	8.9	6.3	.513	.609

Components	% of household		*t*	*p*
	Lower access	Higher access		
Punishment for damaging others' rights				
Yes	7.1	14.6	-1.227	.223
No	1.8	4.2	-.697	.488
Not always	57.1	56.3	.091	.928
Mutually solved	16.1	8.3	.159	.874
Bribe if required	17.9	16.7	1.186	.238
React against any threat				
Money	64.2	83.3	-2.213	.029
Flee away	5.4	4.2	.283	.778
Apologise	3.6	6.3	-.619	.538
Mutually solve	32.1	52.1	-2.082	.040
No need to react	7.1	2.1	1.199	.233
Failed to react	19.6	4.2	2.423	.017
Able to achieve in anyway (interference or hindrance)				
Always	3.8	2.3	.457	.649
Mostly can	17.3	18.6	-.081	.936
Neither nor	9.6	16.3	-.880	.381
Mostly not	48.1	51.2	-.120	.904
Never	21.2	11.6	1.324	.188
Economic freedom				
Open markets for everyone	98.2	97.9	.109	.913
Can produce free whatever wants to	100	100	-	-
Can extract and sell the forest resources freely	100	100	-	-

Villagers from each group (LA: 16%, HA: 19%) reported that NGOs encouraged them to reduce their dependency on the forest and almost all interviewees reported that there was nobody to defend their rights to collect ESS. Some of them suggested that NGOs were slightly vocal in defending their livelihood rights but it did not make any difference (Table 6.4).

In the study area most of the villagers were not free to do what they preferred for their wellbeing (LA: 61%, HA: 56%) compared to those that felt moderately free (LA: 9%, HA 17%) and those that felt greater freedom (LA: 30%, HA: 29%). Within household types, HA (58%) households respected each other's rights more than LA (51%) families, which may be due to the higher accessibility of HA to ESS over LA families. That being

said, more HA (64%) families reported facing greater challenges from pirates, other villagers, and the environment while collecting ESS than LA group (59%). HA families (58%) were able to achieve greater respect in the society than LA families (51%). Although more than half of the households from each group agreed that punishment was always ensured for any wrongdoing, a greater number of HA families (15%) could secure justice. The tendency to mutually solving any issue was greater among LA families (16%) then the HA group (8%) but some families from both LA (18%) and HA (17%) groups reported bribery during Samaj's trial (communal trial) (Table 6.4).

6.3.4 Health and sanitation

It was found that HA families, who had greater access to PS collection, reported significantly lower levels of physical strength compared to LA collectors ($t = -2.803$; $p = 0.007$). In terms of strength, it was found that more than half of the HA collectors were physically weak while only 25% of LA collectors generally felt weak. Based on the response to the question "how much do you know about health, diseases and causes, sanitation and precautions to avoid diseases?" more than quarter of the LA families had very low health knowledge, but this was significantly higher than HA families (10%) ($t = 2.137$; $p = 0.035$) (Table 6.5).

A significantly higher number of LA families (27%) were reported having fairly high self-esteem compared to HA families (10%; $t = 2.137$; $p = 0.035$) primarily because LA households could join any sort of activity while HA families would hesitate due to the social status. There was significantly (disagree somewhat: $t = -2.058$; $p = 0.042$) greater number of HA (35%) families than LA (18%) households who disagreed that they have high self-esteem. A significantly higher number of LA households (43%) mentioned that they rarely get angry with their family members or neighbours than of HA households

(19%) (t = 2.699; p = 0.008) (Table 6.5). These demonstrate that higher access to ESS exposed people to higher competition and risks which eventually affect the mental health of the collectors.

Table 6.5: Comparing health and sanitation between lower and higher access groups around the Sundarbans Mangrove Forest.

Components	Lower access	Higher access	*t*	*p*
Physical health (% of HH)				
Physically feels weak				
Strongly agree	21.4	27.1	-.668	.506
Agree some extent	5.4	25.0	-2.803	.007
Neither agree nor disagree	28.6	25.0	.406	.686
Disagree some extent	16.1	6.3	1.566	.120
Strongly disagree	28.6	16.7	1.437	.154
Diseases per year (frequency/yr)				
Male	5.12	5.06	.138	.891
Female	4.13	4.56	-.800	.426
Children	5.48	5.72	-.218	.828
Chronic health issues (% of HH)				
Male				
Broken limb	1.8	2.1	1.320	.190
Diabetes	1.8	-	1.000	.322
Piles	3.6	4.2	.889	.376
Hypertension	1.8	-	1.000	.322
Lower back pain	1.8	2.1	-.108	.914
Female				
Lower back pain	7.2	-	1.632	.106
Hypertension	1.8	4.2	-.718	.474
Children				
Asthma	-	2.1	-1.081	.282
Health awareness				
Toilet facility				
Sanitary	98.2	100	-1.000	.322
Unsanitary	1.8	-	-1.000	.322
Knowledge of health				
Very low	26.8	10.4	2.137	.035
Low	50.0	54.2	-.420	.675

Components	Lower access	Higher access	*t*	*p*
Moderate	17.9	22.9	-.631	.529
High	5.4	12.5	-1.289	.200
Mental health (% of HH)				
Generally feels happy				
Strongly agree	14.3	14.6	-.043	.966
Agree some extent	19.6	20.8	-.149	.882
Neither agree nor disagree	39.3	31.3	.851	.397
Disagree some extent	19.6	22.9	-.402	.688
Strongly disagree	7.1	10.4	-.587	.558
Self-esteem is high				
Strongly agree	32.1	27.1	.558	.578
Agree some extent	26.8	10.3	2.137	.035
Neither agree nor disagree	10.7	10.4	.049	.961
Disagree some extent	17.9	35.4	-2.058	.042
Strongly disagree	12.5	16.7	-.593	.555
Regularly stressed				
Strongly agree	55.4	41.7	1.393	.167
Agree some extent	16.1	27.1	-1.370	.174
Neither agree nor disagree	14.3	14.6	-.043	.966
Disagree some extent	14.3	16.7	-.331	.742
Strongly disagree	-	-	-	-
Regularly angry				
Strongly agree	12.5	12.5	-	-
Agree some extent	10.7	20.8	-1.426	.157
Neither agree nor disagree	25.0	35.4	-1.154	.251
Disagree some extent	42.9	18.8	2.699	.008
Strongly disagree	8.9	12.5	-.579	.564

6.3.5 Security

Higher access to PS tends to significantly reduce (LA: 25%, HA: 8%) dependency on the neighbours for emergency money ($t = 2.274$; $p = 0.025$). The ability of HA families to manage money was also significantly higher than LA households (easy: $t = -5.741$; $p = 0.001$; very difficult: $t = 6.620$; $p = 0.001$). In the case of emergency, money people were

mostly reliant on microfinance organizations (LA: 73%, HA: 87%). Most of the households (80%) from both categories reported a very high sense of security at the individual level. However, a few families did mention occasional incidences of theft (LA: 4%, HA: 6%).

The certainty of livelihood activities was higher among HA families (48%) than LA families (37%), more than half of the respondents reported that they were very likely to get ESS in the forest, although nearly a quarter of them said they were not always able to access ESS when needed. The insecurity of livelihood activities inside the forest was primarily because of pirate attacks, as well as partly because of the dangerous wildlife (including the Royal Bengal Tiger, crocodiles and snakes). People termed the wildlife as the police of the forest. They were free to sell the ESS to the local market as well as to a merchant onsite (Table 6.6).

Table 6.6: Comparing security levels between lower and higher access groups around the Sundarbans Mangrove Forest.

Components	% of households		*t*	*p*
	Lower access	Higher access		
Personal security is good				
Strongly agree	80.4	79.2	.149	.882
Agree some extent	16.1	14.6	.208	.835
Neither agree nor disagree	1.8	2.1	-.108	.914
Disagree some extent	1.8	4.2	-1.545	.125
Strongly disagree	-	-	-	-
Certainty in livelihood activities				
Strongly agree	23.2	31.3	-.909	.366
Agree some extent	14.3	16.7	-.331	.742
Neither agree nor disagree	25.0	14.6	1.318	.191
Disagree some extent	19.6	20.8	-.149	.882
Strongly disagree	17.9	16.7	.159	.874
Certainty of ESS				

Components	% of households		*t*	*p*
	Lower access	Higher access		
Strongly agree	53.6	58.3	-.484	.630
Agree some extent	14.3	12.5	.265	.792
Neither agree nor disagree	7.1	6.3	.180	.857
Disagree some extent	23.2	22.9	.036	.972
Strongly disagree	1.8	0	1.000	.322
Health insurance				
Yes	3.6	4.2	-.155	.877
No	96.4	95.8	.155	.877
Emergency money				
Source				
Neighbours (with interest)	25.0	8.3	2.274	.025
Local lenders (with interest)	1.8	0	1.000	.322
Microfinance organization	73.2	87.5	-1.545	.125
Ability to manage				
Easy	0	37.5	-5.741	.001
Moderately	1.8	56.3	-7.818	.001
Difficult	50.0	6.3	5.478	.001
Very difficult	48.2	0	6.620	.001
Impossible	-	-	-	-

6.3.6 Social relations

A significantly higher number of LA households (4%) were in a very distant relationship with the rest of the society than of HA families (15%) (t = 2.068; p = 0.047). No other elements related to social relations seemed to differ significantly between the groups. A very high degree of distrust was observed between HA households (55%) and the rest of the society, which was very high in comparison to the LA families (34%). Trust in government officials was generally low across the villagers (LA and HA: 64%). Financial assistance from neighbours and relatives was very rare as almost all of the households (LA: 93% and HA: 98%) reported that there was nobody these days come forward with money to help them. But in terms of non-financial assistance, half of the population from both household categories found their neighbours and relatives beside them in need of help (Table 6.7).

More than half (LA: 55%, HA: 63%) of the population were likely to join forest protection activities and almost all the villagers mentioned that they would join in attempts to protect the forest. On average, households of LA and HA categories were members of 1.36 and 1.38 livelihood groups, respectively. Within the village, LA families had a higher number (10) of close members than HA families (8). Reciprocity and participation in ceremonies were two major indicators of social cohesion that were similar between the groups (Table 6.7).

Table 6.7: Comparing good social relations between lower and higher access groups to ecosystem services around the Sundarbans Mangrove Forest.

Components	Lower access	Higher access	*t*	*p*
Trust and solidarity relations (% of HH)				
Most of the people are trusted				
Strongly agree	25.0	27.7	-.239	.812
Agree some extent	30.4	14.9	1.634	.105
Neither agree nor disagree	10.7	8.5	.410	.682
Disagree some extent	17.9	34.0	-1.829	.070
Strongly disagree	16.1	14.9	.208	.835
How much local govt./authority is trusted				
Low	64.3	63.8	.187	.852
Moderate	14.3	8.5	.959	.340
High	-	-		
Not at all	21.4	27.7	-.664	.509
Many people are willing to financial help				
Strongly agree	3.6	-	1.320	.190
Agree some extent	3.6	2.1	.448	.655
Neither agree nor disagree	-	-	-	-
Disagree some extent	19.6	10.4	1.298	.197
Strongly disagree	73.2	87.5	-1.821	.072
Most of the people willing for non-financial help				
Strongly agree	32.1	27.1	.560	.577
Agree some extent	17.9	25.0	-.875	.384
Neither agree nor disagree	1.8	2.1	-.108	.914
Disagree some extent	32.1	29.2	.325	.745
Strongly disagree	16.1	16.7	-.081	.936
Collective action and				

Components	Lower access	Higher access	*t*	*p*
cooperation (% of HH)				
How likely people work for protecting forest				
Very likely	28.6	39.6	-1.181	.240
Somewhat likely	26.8	22.9	.452	.652
Somewhat unlikely	35.7	31.3	.477	.634
Very unlikely	8.9	6.3	.513	.609
How often you attend community activities	-	-	-	-
How many people work together in protecting forest				
Everyone	16.1	25.0	-1.127	.262
Most of the villagers	19.6	18.8	.114	.909
About half of the villagers	28.6	25.0	.407	.685
Few	35.7	27.1	.943	.348
Nobody	-	4.2	-1.545	.125
Groups and network				
Group membership (No.)				
Livelihood group (informal)	1.36	1.38	-.133	.894
Co-operatives	0.48	0.67	-1.308	.195
Others (e.g. mosques, temple)	0.43	0.66	-1.059	.293
Cooperation with other groups				
Frequently	-	-	-	-
Occasionally	-	-	-	-
No	100	100	-	-
Close friend/families (No.)	9.93	7.87	.914	.363
Social cohesion (% of HH)				
Togetherness				
Very distant	3.6	14.6	-2.011	.047
Somewhat distant	23.2	8.3	2.068	.041
Neither distant nor close	25.0	33.3	-.924	.358
Somewhat close	44.6	35.4	.954	.343
Very close	3.6	8.3	-1.004	.319
Sharing ESS (No. of households)	2.60	3.04	-1.421	.158
Ceremony attendance in last 12 months (No.)	7.79	10.4375	-.953	.343

Note: [d] represents values with different unit.

6.3.7 Composite scores of wellbeing

The mean wellbeing in physical health was close to high in both categories of households (LA: 3.5, HA: 3.7), but a significant difference was observed in the physical health of the

two access groups (t = -2.330; p = 0.022). HA households were able to collect more PS than LA families which eventually ensured greater wellbeing of the families. The wellbeing status of emergency financial assistance was significantly higher across LA families (3.5) than HA families (1.7) (t = 15.955; p = 0.001) (Table 6.8). This possible reason may be the HA families generally require higher levels of financial assistance than LA families. The higher the amount of money required, the lesser the source becomes available. But there was no significant difference between the two groups in other types of wellbeing. This clearly entails that only the Sundarbans forest is not sufficient to ensure greater wellbeing of the people, though this forest is a vital part of their wellbeing.

Table 6.8: Comparing wellbeing scores of lower and higher access groups around the Sundarbans Mangrove Forest.

Wellbeing criteria	Lower access				Higher access				*t*	*p*
	Min	Max	Mean	SD	Min	Max	Mean	SD		
Water for other purpose	3.83	4.83	4.45	.246	4.00	4.83	4.37	.203	1.846	.068
Water for drink	2.71	4.29	3.84	.360	3.00	4.43	3.87	.338	-.516	.607
Food availability	1.33	4.67	2.94	.830	1.33	4.33	2.88	.770	.335	.738
Physical health	2.67	4.56	3.88	.474	3.11	4.56	4.08	.327	-2.330	.022
Mental health	1.00	4.25	2.94	.693	1.75	3.75	2.77	.584	1.372	.173
Personal security is good	1.00	5.00	4.73	.674	2.00	5.00	4.69	.719	.325	.746
Certainty of employment	1.00	5.00	3.05	1.420	1.00	5.00	3.25	1.509	-.680	.498
Certainty of ESS availability	1.00	5.00	3.95	1.313	2.00	5.00	4.06	1.262	-.459	.647
Emergency money manageability	2.00	4.00	3.46	.538	1.00	3.00	1.69	.589	15.955	.001
Trust and solidarity relations	1.25	4.00	2.46	.656	1.25	3.50	2.31	.597	1.260	.210
Collective action and cooperation	1.50	5.00	3.23	1.128	1.50	5.00	3.45	1.081	-1.043	.300

Wellbeing criteria	Lower access				Higher access				*t*	*p*
	Min	Max	Mean	SD	Min	Max	Mean	SD		
Groups and network	1.00	3.00	1.88	.533	1.00	3.75	1.95	.594	-.661	.510
Social cohesion	1.50	5.00	2.92	.706	1.00	5.00	2.88	.802	.299	.766
Social Freedom	1.67	3.50	2.55	.508	1.50	3.50	2.65	.497	-.899	.371
Economic freedom	4.67	5.00	4.99	.044	4.67	5.00	4.99	.048	.108	.914
Institutional protection	1.50	2.67	1.92	.318	1.67	2.83	2.03	.368	-1.684	.095

6.4 Discussion

Higher access to PS eventually tends to significantly worsen the food security situation of the families. Increase in income due to higher access, changes the family demands for both quality and quantity of food. They spent more of their income for purchasing costlier food items from the market which led them to eat a smaller amount of food. Alinovi *et al.* (2008) found that in Lao PDR a one percent increase in income leads to a 2.4% increase in food expenditure in low income families. Villagers were thus, vulnerable to market price fluctuation. Any increase in food prices would eventually accelerate ESS collection, and LA families were more likely to fall into deeper food insecurity (Akter and Basher, 2014). Thus, any attempt to increase the income of the ecosystem dependent communities by assuming that higher income would deter people from extracting PS should be carefully implemented. Otherwise, the strategy could lead to more forest dependency and eventually more ecosystem degradation (Sunderlin *et al.*, 2005). People could not afford good quality water for other purposes such as bathing, washing clothes and utensils, hence ponds or a salty river were the only options. People were not able to make enough money from PS collection to pay for fresh water. Moreover, there was no running water supplied to the villages by the local municipality. Buying water and carrying the water containers to the house was not financially or physically feasible either. Hence, they had to depend on the salty river water near their village which was a major health concern.

Islam and Gnauck (2008) reported that a harmful level of salinity in the rivers around the Sundarbans forest is one of the problems of the area. Addressing the problem of water could be a key criterion to improve because they live near a mangrove forest.

Studies show that any employment with minimum work-family interaction reduces conflict within the family as well as the society (Parasuraman and Simmers, 2001, Toth *et al.*, 2002). But it was found that with an increased access to PS, people's intention to find a mutual solution for a dispute was likely to decrease because of the significant increase in the capability of standing up against any injustice. Social conflicts were resolved in the 'Somaj Salish' (village judicial body) which was dictated by the elites and wealthy people. Villagers complained that the 'Somaj Salish' was a corrupted system and the poor often failed to get the justice they deserved. This might lead victims to suffer from unequal access to the resources and necessary facilities, and thereby, reduce wellbeing. Greater equity in terms of ecosystem benefits would potentially contribute to the better conservation of the ecosystems (Corbera *et al.*, 2007, Larson *et al.*, 2008).

Higher access tends to negatively affect the physical and mental health of the collectors. In this study, I observed that increased access to PS also significantly increased the frequency of anger of a household head, which is generally directed at family members and/or neighbours. PS collection required living inside the forest, sleeping on a small boat and eventually little to eat. Moreover, increased profits caused higher competition between neighbours, and greater family demand. In many studies, it is reported that isolation, sleep deprivation, and improper nutrition deteriorate the physical and mental health of the collectors (Mullington *et al.*, 2009, Müller and Krawinkel, 2005, Seeman, 1996, Osborn, 2001, Kemp and Quintana, 2013). Composite scores of wellbeing categories suggest that the most significant contribution of PS was in improving the physical health condition of the families: the household head is sacrificing his/her

wellbeing for the betterment of the family, i.e. higher access may not benefit the collector's health positively, but it does benefit the family as a whole.

With the increased access to ESS, trust between the villagers and network of the households was increased. There was a significant reduction in dependence on neighbours for emergency money because of higher income from ESS, instead, people primarily relied on the bank/microfinance organization. Therefore, any destruction of ESS in the Sundarbans would hit the dependent communities very hard. Hogarth *et al.* (2013) also reported higher dependence of the poor people in southern China on the forest making them more vulnerable due to the monopolized off-farm income by the higher income groups. On the other hand, access to ESS had negative effects on solidarity relations. Collecting ESS from a mangrove forest requires a group of people with close ties to enter the forest for several days to a month. As collecting PS was the major livelihood activity and crucial for their survival, they always tried to maintain relations with few other members. Splitting the groups and formation of new ones were common in the village which also happened due to the closeness of the members. Hence, the solidarity remained limited to several households. Edmunds and Wollenberg (2001) also argued that solidarity is always provisional and biased by certain groups of the stakeholders. Despite a significant improvement in social cohesion, higher access would likely to make people more reluctant in collective action to conserve the forest. Higher earnings from the forest PS made many people reluctant to conserve the resources. Moreover, the people involved in a collective forest conservation effort were primarily engaged in NGO projects from which they were given financial or physical or social benefits. Sunderlin *et al.* (2005) reported that the forest beneficiaries who could gain higher access are often engaged in destructive competition instead of joining in collective action for forest conservation.

This study finds that the Sundarbans forests are not sufficient per se, to make a significant change in human wellbeing across the dependent communities because of growing population pressure and depletion of the valuable PS form the forest. Globally mangrove forests are in decline due to high pressure from the dependent communities (Giri *et al.*, 2011, Alongi, 2002). They are the some of the most vulnerable people, and the mangrove forest supplies them essential foods and shelter to make them more resilient (Alongi, 2008). The concept of improving people's income by increasing access to the PS would further accelerate over-exploitation. Other development programs such as water and sanitation, education, and psychological and social improvement are essential to be incorporated into conservation efforts to enhance wellbeing and, eventually, forest ESS conservation.

6.5 Conclusion

ESS have a significant influence on the wellbeing of the dependent communities. In this study, I found that social freedom, social cohesion, and economic security tend to be significantly increased with a higher level of ESS extraction, whereas food sufficiency was significantly reduced with an increase in ESS collection. This entails that if the economic status of the people increases, their demand for food also increases, which becomes even harder to afford. In case of the mental and physical health of the collectors, there was a significant negative impact as a result of higher amounts of ESS collection. These results demonstrate that without robust attention to the wellbeing of the dependent people, a program will not secure sustainable conservation of the forest. Sole dependence on the ESS from forest ecosystems, per se, would not generate sustainable conservation output. My research suggests that without incorporating other development initiatives with the sustainable management programs, apparently it would be impossible to save our ecosystem from unsustainable exploitation.

Chapter 7

Discussion and Implications for Conservation Management

Owing to the fact that ESS have been largely ignored in forest and environmental policies, forest ecosystems have been undervalued in terms of their financial benefits and how they impact the livelihoods of millions of people. More nuanced and complete case studies are needed to fully quantify and qualify the values of forest ESS throughout the world and investigate how they contribute to the livelihood of people as well as the financial benefit they may offer. This thesis aims to do just that through the use of four case studies from two forests in Asia.

The first two case studies were done at VSSPNP. This forest contains significant populations of rare and endangered species including Northern buff-cheeked gibbons (*Nomascus annamensis*). The next two case studies were done at Sundarbans Mangrove Forest (SMF) which is a world heritage site declared by the UNESCO. This forest is the single largest mangrove forest in the world and home to many endangered wildlife species. Using these two important forests, this research project aimed to answer four key research questions:

1. What is the estimated value of the Ecosystem Services of VSSPNP?
2. What are the potentials of recreational service based management in sustainable conservation at VSSPNP?
3. What are the interactions between livelihood capitals and access of local communities to the forest ecosystem services and how does this impact their daily lives and wellbeing at SMF?
4. What are the potentials of ecosystem services for improving the human wellbeing of directly dependent communities in at SMF?

7.1 Ecosystem Services at Veun Sai- Siem Pang National Park, Cambodia

7.1.1 The value of the forest ecosystem

I estimated the total annual contribution of VSSPNP was US$129.84million, which was made up of contributions from air purification, water storage, soil-erosion reduction, soil-fertility improvement, carbon sequestration, provisioning services and recreation. In Mundulkiri and Koh Kong, the biodiversity corridor is worth US$3815ha^{-1}yr^{-1} (ADB, 2010). Although there are two more ESS included in this study, per hectare value of VSSPNP's ESS (US$2334ha^{-1}yr^{-1}) suggests that the site is equally valuable with other nationally important ecosystems. Traditionally the forest is used for timber and non-timber forest products, however, this composed only 1.36% of the total benefits. The enormous contributions of the ecosystems to our economy and wellbeing are crucial for all of us particularly for the adjacent local people (Kar and Jacobson, 2012, Angelsen *et al.*, 2014, Ding and Nunes, 2014). For example, forest destruction would accelerate soil erosion which eventually would reduce water quality of the nearby streams and rivers upon which everyday life of local people are very much dependent. This degradation would create a snowball effect to the public health in the locality as well as the local economy and eventually to national economy and politics. Moreover, not only ESS are contributing to the economy, it is also creating invaluable knowledge and collaboration, and have been acting as a base for myriad cultural elements of many communities. These values can be made even higher by properly managing the ecosystem, and thereby, enhance human wellbeing. Thus, destruction of the forest ESS would eventually put more pressure on many sectors of both onsite and offsite population.

7.1.2 Community-based management of human wellbeing

One way that we may be able to protect the ecosystem and increase its value is through tourism based on the iconic species present in the park. The CBET (Community Based Ecotourism) program currently in place in the national park is focused on the rare gibbons conservation in VSSPNP. The gibbons enhanced the recreational value of the forest and there was a significant improvement in the level of satisfaction of the tourists after visiting the site. In many studies, it has been proven that iconic species greatly improve the satisfaction level of tourists (Ziegler *et al.*, 2012, Okello and Yerian, 2009, Ballantyne *et al.*, 2011). However, CBET was unable to improve the wellbeing of the local indigenous communities in Cambodia at its full potential. Before CBET, the indigenous people felt there was nobody to help improve their livelihoods but with the initiation of CBET this long-held perception had been significantly overturned. In addition, although CBET was reported to restrict the freedom of local communities to continue their traditional livelihoods, they were free to maintain subsistence activities. Due to CBET, people's intention for collective action and cooperation for conservation of the forest was also significantly increased. Poteete and Ostrom (2004) argue that carefully formed groups create opportunities for frequent interactions, which facilitates collective action. Moreover, VSSPNP groups were constituted with the indigenous communities who share same social, cultural and economic features, thus this effort had fostered greater cooperation and collective action (Carpenter *et al.*, 2004, Poteete and Ostrom, 2004).

Despite this positive impact on the social aspect of people's lives, there were some ways that locals felt CBET had a negative impact on them. The composite wellbeing score of feeding condition was significantly reduced even after implementation of the CBET program. This may be because of the lower productivity of the ecosystem itself and

restriction imposed on ESS extraction. Moreover, although the earning potential from CBET was quite small, it might still deter people from entering the forest for tedious ESS extractions (Pagdee *et al.*, 2006, Hutton and Leader-Williams, 2003). Our study demonstrates that it will take very long time to substantially increase the wellbeing of the people unless the program is redesigned to achieve more robust outcomes. Thus, without robust attention on the wellbeing of the dependent people, it would be extremely difficult to reach sustainable conservation goals. The traditional ways of enhancing wellbeing by increasing the income of the dependent people would be a very slow process. It is required to address the major wellbeing demands of the people while designing ecotourism projects in order to make greater progress in reducing ecosystem destruction.

CBET program had been able to create some significant improvement in local wellbeing within a short period of time. It would eventually improve local livelihood if the program takes local demands into consideration. The gibbon based CBET program was only possible to implement due to the gibbons (a recreational ESS). Moreover, the value of the forest has been used by the CBET implementing authority to justify their stance to conserving the forest. Very recently, the government has declared the forest a national park. Thus, the valuation has been contributing both at policy and local household level.

7.2 Ecosystem Service of the Sundarbans Forest, Bangladesh

7.2.1 Livelihood capitals and access to ESS

Similar to at VSSPNP, the importance of forest for the subsistence of local people was crucial in Bangladesh, however, due to growing population pressure, the ecosystem solely was unable to supply enough ESS (Provisioning services or PS) to the people to maintain a high level of human wellbeing. When people are restricted in accessing to PS (e.g. honey, mixed fish, shrimp fry, shrimp, and fuelwood) extraction, then access to the

ecosystem becomes the decisive factor in determining the livelihoods (Table 7.1) and wellbeing of dependent communities. This access is also determined by people making investments and trade-offs of their livelihood capitals including human, natural, financial, physical and social capitals (see Table 2.1 for review). This study found that human capitals had a negative effect on the access to most provisioning services which had labour intensive harvesting process. It was surprising that this trend was apparent in all PS examined in this research as it is generally thought to influence certain types of PS extraction over others. For example, enhanced human wellbeing has been known to eventually deter people from all kinds of low-income traditional activities (Stark and Wang, 2002). Thus, improving human capitals of marginalized communities around an ecosystem could play a vital role in sustainable conservation.

Table 7.1: The influence of livelihood capitals to gain access to the ESS in the Sundarbans Mangrove Forest.

	Impact type of livelihood capitals				
PS	Human	Social	Physical	Financial	Natural
honey	⇩		⇩	⇧	⇩
Crabs	⇧	⇩	⇧	⇧	X
Shrimp fry	⇩	⇩	⇧	⇧	X
Shrimp	⇩	⇩	⇧	⇧	⇧
Mixed fish	⇩	X	X	⇩	X
Fuelwood	⇧	⇧	⇩	⇧	X

Note: ⇧ = increase access; ⇩ = decrease access; X= no significant effect.

The effect of physical capitals which were costly but affordable by some people had a positive relation to a particular ESS collection because they remained focused on one specific ESS. Owning a superior technology, tools and equipment act as pull factors of livelihood diversification in the rural areas (Barrett *et al.*, 2001, Sen, 2003). However, the

physical capital that was exclusively affordable by the traders had no effect on the access to PS. Natural capital (land area) had a highly positive impact on the access to the PS which was cultivated on their land because they were well informed about the business of the resource. Financial capital had a strong positive impact on the access to the independently collectible PS, while social capitals had a strong negative impact on the access to such PS. Social capital showed a weak negative impact on the access to PS that required a higher investment of the other capitals. Barrett *et al.* (2001) showed that financial capital is one of the most important sets of motives of the people in diversifying their livelihoods.

7.2.2 ESS and human wellbeing

Only enhancing access to ESS would not be able to ensure higher wellbeing in many aspects of the dependent families. Despite having adequate access, there was no significant change in most of the indicators of basic materials of good life, security, social relation, health condition, and freedom of choice and action. In some cases, higher access had negative effects on the wellbeing. For instance, higher access degraded the physical health condition of the collectors because they spent more time to do physically demanding ESS harvesting. ESS contributed significantly to the availability and cleanliness of the non-drinking water. Food sufficiency was significantly decreased with the increase in access to ESS collection. Under the category of 'freedom of choice' ESS was likely to significantly improve the capacity of the people to maintain social freedom, despite the significant increase in the level of obstruction to livelihood. Fa *et al.* (2003) showed that restriction in ESS collection for sustainability would eventually increase the food insecurity of the dependent local communities as they have very limited alternative sources of foods and non-farm activities to earn money for buying food. A higher amount of ESS extraction tends to significantly weaken the collectors physically. Mental health

variables including self-esteem showed significant decrease and anger level had significantly increased with the increased amount of ESS collection. But community-based program had no effect on the mental health of the people in Cambodia i.e. community engagement in conservation would reduce conflicts with the authorities as well as the family members of the collectors which eventually improve physical health. The ability to secure some money in case of emergency was tended to significantly increase due to a higher level of ESS extraction. ESS collection was likely to increase social cohesion significantly by increased level of ESS extraction in the Sundarbans of Bangladesh. Similarly, in VSSPNP of Cambodia, it was found that recognizing people's rights to live on ESS eventually enhance social cohesion by developing social groups which could significantly increase the collective action and cooperation among the villagers. The negative effect of hardships in collecting ESS was observed both in Cambodia and Bangladesh. Thus, without ensuring alternative livelihood opportunities, enhancing people's access to the ecosystem might have harmful effects on both human and ecosystem. The wellbeing of nature-dependent communities has already been undermined by the hardships in collecting ESS (e.g. overnight stay in the forest, and risk of wildlife and insects), and inadequate facility for processing, storage, transportation and marketing of ESS (Maraseni *et al.*, 2006, Babulo *et al.*, 2009). Higher access would encourage overexploitation of ESS and initiate more competitions across the society. However, overall physical health and economic security of the families would significantly improve with the increase in ESS collection. This represents that collectors would harvest ESS by sacrificing their health and mental condition which may have a positive effect on the family in the short run but the family would suffer in the long run due to the diminishing productivity of the collectors. Abdulai and CroleRees (2001) also showed that the more capable the household head, the more prosperity occurs in the families. Therefore, conservation programs in South and South-east Asia require

integrating other human wellbeing improving activities in order to achieve sustainable ecosystem management.

7.3 Importance of these forests for the subsistence of local people

VSSPNP in Cambodia supplies ESS to the local indigenous people which are crucial for their subsistence. People collected almost all their foods from the forest including mushroom, bamboos shoot, cane shoot, water, bush-meat, medicinal plants etc.; construction materials including timber and poles. Similarly, SMF in Bangladesh supports the people around the forest by supplying many ESS including mixed fish, honey, shrimp, shrimp fry, crabs, water etc.; construction materials including timber, tree poles, thatching materials; cooking energy material such fuelwood. As SMF is a mangrove ecosystem, people relied on the ESS primarily to generate income. But one commonality between these marginalized people in both countries was their heavy dependence on the ecosystem for subsistence. In SMF, there were restrictions in practice to collect ESS but in VSSPNP the restrictions were in papers only. In reality, it was observed that villagers were engaged in all kinds of illegal harvesting of ESS especially cutting trees and hunting wild animals without any apparent obstruction. Local public authority and traders were involved in the lucrative business of ESS. McElwee (2004) also reported that local people were able to continue illegal activities in the north-eastern part of Cambodia because of the collusion among the public officials in both Cambodia and Vietnam. The SMF in Bangladesh informs us two important things; firstly, if the government respects people's rights on the ecosystem, they are willing to accept the regulations; and secondly, government must take strong initiatives to stop the influential people benefiting from the ecosystem dependent communities' poverty and their rights on the forest for subsistence.

Due to official restrictions, and bringing the local influential people and the traders/merchants under formal management practice there was a high level of restriction for everyone in illegal harvesting in SMF in Bangladesh. Thus, the authority was able to reduce the illegal activities by the people. On the other hand, people (both villagers and traders) in VSSPNP in Cambodia were not put under any well-organized formal procedure to collect ESS. Hence, all the stakeholders were inclined to maximize their profits/benefits which facilitated unsustainable collection of ESS and high level of corruption in managing the forest. Thus, my research suggests that every stakeholder who benefits from the ESS extraction should be recognized and brought under appropriate legal obligations. Inclusion of broad range of stakeholders in decision making in forest conservation would facilitate more informed and creative response to the issues of concerns, and thereby, would eventually lead to minimizing the ecosystem destruction and maximizing local wellbeing (Fish *et al.*, 2011, Antunes *et al.*, 2006, Young *et al.*, 2013).

The most important category of the ESS is provisioning services (e.g. food and construction materials), essential to meet the household needs of the dependent people. They also sold valuable products such as timber, resin to make money for their families. On the other hand, because of being a mangrove ecosystem people around SMF of Bangladesh mostly collected ESS for generating income to buy items to meet their family needs. Therefore, the purpose of harvesting in a locality should be carefully identified in order to design a conservation program for an ecosystem on which adjacent communities were heavily dependent. Addressing the demand for subsistence and the locality as a whole, either for direct consumption or income, are vital in sustainable conservation because demands from indirectly dependent communities may have detrimental effects in ecosystem conservation initiatives (Scheffers *et al.*, 2012, Ndangalasi *et al.*, 2007).

Hardships in harvesting ESS and lower market price of the goods were demotivating factors for continuing their heavy dependence on the ESS. But lack of alternative income sources they had no option but collecting ESS to maintain their wellbeing. In both forests, I found that people had been looking for the opportunities to escape from the vicious cycle or at least thinking to manage something to get their next generation out of the low productive livelihood activities because they realized that ESS were not infinite (Byron and Arnold, 1999). If the issue is not rightly addressed, this could either reduce or accelerate deforestation (Hecht *et al.*, 2015). The eagerness of the nature-dependent people to accept livelihood improving programs could be vital to implement sustainable conservation projects in any developing countries of Asia.

7.4 Implications of results for conservation management

7.4.1 The VSSPNP

The total ESS value of VSSPNP would greatly support NGOs (e.g. Conservation International) in convincing policymakers to ensure proper management of VSSPNP and lead to sustainable policy formulation. This significant result would be a valuable element in deciding trade-offs between forest conservation and utilization. For instance, it would assist in checking the viability of leasing forest land for converting to sugarcane or rubber plantation which are popular to the Khmer government but unreasonable in terms of sustainable development. VSSPNP in North-eastern Cambodia has been listed as a Key Biodiversity Area in the World Biodiversity Database (Chan *et al.*, 2004). The area is a part of the 200 globally most important ecoregions, the Eastern Indochina Dry and Monsoon Forest (Olson and Dinerstein, 1998). Primates of this area are of special conservation concern and of particular interest for conservation is the population of Northern buff-cheeked crested gibbon (*Nomascus annamensis*) found at the site as it is

considered to be the biggest population of the species *Nomascus annamensis* in existence (Rawson *et al.*, 2012). Despite rich biodiversity and great contribution of the forest, little has been done thus far by the international community to effectively conserve the unique biodiversity of this region. Conservation International has been implementing a CBET program to conserve some gibbons and their habitat. However, a vast majority of the forest remains virtually unprotected. Additionally, the CBET program is narrowly focused on increasing income of the local people and this scope needs to be widened to address other community needs. Moreover, more resources need to be incorporated to successfully implement current and new CBET programs to protect the entire forest. The results obtained in this study regarding the value of various ESS present in VSSPNP can be extrapolated out to other forests in South and Southeast Asia with similar resource bases. It is essential to explore the true contribution of the forest ecosystem of the region to understand the potentials of the ecosystems in improving human wellbeing. A wider understanding of the human-ecosystem relationship is also essential to designing sustainable conservation programs. This kind of evaluation could provide essential guidelines 'Environmental Impact Assessment' of any development project to achieve sustainable development. The study would assist decision makers to understand the true cost forgone by converting a natural ecosystem (e.g. forest) to other land uses. Moreover, this thesis identified indicators of the parameter of human wellbeing which also could be used to other projects to understand the effect of a certain project on the local wellbeing.

Management goals aimed at maintaining the key services of a forest ecosystem also has the potential to improve the wellbeing of the local people and reduce unsustainable exploitation of the services. The iconic Northern buff-cheeked crested gibbon species potentially increased the importance of the whole forest ecosystem. CBET program was designed by using the recreational value of the threatened species. Within a short period

of time, the site started to get growing interests from tourists. The primary aim of the project was to engage local people in CBET program who were otherwise the illegal loggers and hunters, and thereby, increase their income and capacity to sustainable ecosystem management. There was a significant improvement in 'collective action and cooperation' due to joining the program as participants. And their food security condition and social freedom was significantly reduced because they started to realize the importance the forest ecosystms, hence reduced their extraction as part of the contract with the CBET authority. Currently, the project has successfully created a positive impression about ecosystem conservation and mobilized the community to participate in conservation initiatives. Robust attention should be given to improve the wellbeing attributes of the local participants including tangible and intangeible benefits. More joint venture initiatives are essential to adequately serve the tourists and popularize the ecotourism site to the future tourists.

7.4.2 The SMF

Every individual human has their own set of livelihood capitals (human, natural, physical, financial and social) based on which a person can decide to consume a particular resource which eventually determines the level of access. It is therefore the "ability" not the "right" that ensures access to any resources. Access to ESS is essential for the wellbeing of ecosystem-dependent communities. The ability of a household to benefit from an ecosystem is a result of the interactions among the various components of the livelihood capital of the households. The stakeholders involved in gaining access to the ecosystem are diverse and equally important. For example, the wealthier merchants supplies necessary capitals to the poor to collect resource and sell to them (merchants). In any initiative for ecosystem management if the poor people are targeted only to deter from the overexploitation is deemed to be failed. The interactions between livelihood capitals

ultimately determine any activity of a household. However, the effects of the interactions may vary between the families. Therefore, access to any resource is not granted; instead, it is achieved by the complex interactions among the range of livelihood capitals. At present without properly understanding the interactions of the livelihood capitals and their relations with the ecosystem, most of the program are commenced and thereby failed to address the need of the people. This eventually leads to least success of a conservation project. Only increased availability or granting legal permission would not ensure proper access to the ecosystem resources. This is a valuable input for explaining the questions remained in understanding the relationship between the ESS and human wellbeing. This will inspire future research to understand the complex interaction of the capitals in achieving individual or collective wellbeing.

ESS have a significant influence on the wellbeing of the dependent communities. Without the forest ecosystem, the people around Sundarbans cannot live their life. In this study, I found social freedom, social cohesion, and economic security tend to be significantly increased with a higher level of ESS extraction. But food sufficiency was significantly reduced with an increase in ESS collection. In terms of the mental and physical health of the collectors, higher amounts of ESS collection had also a significantly negative impact. Sole dependence on the ESS from forest ecosystems, per se, would not generate sustainable conservation output. It is essential to have wider understanding the baseline condition of wellbeing components of a society depended on the ecosystems and then explore which components can be improved at which level. The remaining components of wellbeing which cannot be improved by relying on ESS should be addressed by other development programs. Before designing a project of sustainable conservation, community needs to be extensively studied. If the local needs cannot be addressed by only one conservation project, other projects (e.g. project for water, health & sanitation, education etc.) should be integrated with to give a boost to the conservation initiatives.

Any delay in improving human wellbeing nearby the valuable ecosystem would be counterproductive. Thus, without incorporating other development initiatives with the sustainable management programs, the unsustainable exploitation could not be addressed properly.

References

Abdulai, A. & CroleRees, A. (2001) Determinants of income diversification amongst rural households in Southern Mali. *Food Policy,* **26,** 437-452.

Abdullah, M., Abu, N., Stacey, N., Garnett, S.T. & Myers, B. (2016) Economic dependence on mangrove forest resources for livelihoods in the Sundarbans, Bangladesh. *Forest Policy and Economics,* **64,** 15-24.

Abraham, A., Sommerhalder, K. & Abel, T. (2010) Landscape and well-being: a scoping study on the health-promoting impact of outdoor environments. *International Journal of Public Health,* **55,** 59-69.

Adam, Y.O., Pretzsch, J. & Pettenella, D. (2013) Contribution of Non-Timber Forest Products livelihood strategies to rural development in drylands of Sudan: Potentials and failures. *Agricultural Systems,* **117,** 90-97.

Adams, W.M. & Infield, M. (2003) Who is on the Gorilla's Payroll? Claims on Tourist Revenue From a Ugandan National Park. *World Development,* **31,** 177-190.

ADB (2010) Regional: Greater Mekong Subregion Biodiversity Conservation Corridors Project. *Valuation of Ecosystem Services of Biodiversity Conservation Corridor in Mondulkiri and Koh Kong, Cambodia*, pp. 1-7. Asian Development Bank

Adhikari, B. (2005) Poverty, property rights and collective action: understanding the distributive aspects of common property resource management. *Environment and Development Economics,* **10,** 7-31.

Adhikari, B., Di Falco, S. & Lovett, J.C. (2004) Household characteristics and forest dependency: evidence from common property forest management in Nepal. *Ecological Economics,* **48,** 245-257.

Admassie, A. (2003) Child labour and schooling in the context of a subsistence rural economy: can they be compatible? *International Journal of Educational Development,* **23,** 167-185.

Afenyo, E.A. & Amuquandoh, F.E. (2014) Who Benefits from Community-based Ecotourism Development? Insights from Tafi Atome, Ghana. *Tourism Planning & Development,* **11,** 179-190.

Agrawal, A. & Yadama, G. (1997) How do Local Institutions Mediate Market and Population Pressures on Resources? Forest Panchayats in Kumaon, India. *Development and Change,* **28,** 435-465.

Akama, J.S. & Kieti, D.M. (2003) Measuring tourist satisfaction with Kenya's wildlife safari: a case study of Tsavo West National Park. *Tourism Management,* **24,** 73-81.

Akter, S. & Basher, S.A. (2014) The impacts of food price and income shocks on household food security and economic well-being: Evidence from rural Bangladesh. *Global Environmental Change,* **25,** 150-162.

Akwetairehoa, S. & Getzner, M. (2010) Livelihood dependence on ecosystem services of local residents: a case study from Mabamba Bay wetlands (Lake Victoria, Uganda). *International Journal of Biodiversity Science, Ecosystem Services & Management,* **6,** 75-87.

Alinovi, L., Mane, E. & Romano, D. (2008) Towards the measurement of household resilience to food insecurity: applying a model to Palestinian household data. *Deriving Food Security Information From National Household Budget Surveys. Experiences, Achievement, Challenges. FAO. Rome,* 137-52.

Alongi, D.M. (2002) Present state and future of the world's mangrove forests. *Environmental Conservation,* **29,** 331-349.

Alongi, D.M. (2008) Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science,* **76,** 1-13.

Amacher, G.S., Ollikainen, M. & Koskela, E. (2012) Corruption and forest concessions. *Journal of Environmental Economics and Management,* **63,** 92-104.

Ameha, A., Nielsen, O.J. & Larsen, H.O. (2014) Impacts of access and benefit sharing on livelihoods and forest: Case of participatory forest management in Ethiopia. *Ecological Economics,* **97,** 162-171.

Ananda, J. & Herath, G. (2003) Soil erosion in developing countries: a socio-economic appraisal. *Journal of Environmental Management,* **68,** 343-353.

Anders Gustafsson, Michael D. Johnson & Roos, I. (2005) The Effects of Customer Satisfaction, Relationship Commitment Dimensions, and Triggers on Customer Retention. *Journal of Marketing,* **69,** 210-218.

Andersson, F.O., Feger, K.-H., Hüttl, R.F., Kräuchi, N., Mattsson, L., Sallnäs, O. & Sjöberg, K. (2000) Forest ecosystem research — priorities for Europe. *Forest Ecology and Management,* **132,** 111-119.

Andréassian, V. (2004) Waters and forests: from historical controversy to scientific debate. *Journal of Hydrology,* **291,** 1-27.

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Börner, J., Smith-Hall, C. & Wunder, S. (2014) Environmental Income and Rural Livelihoods: A Global-Comparative Analysis. *World Development,* **64, Supplement 1,** S12-S28.

Angelsen, A. & Kaimowitz, D. (1999) Rethinking the Causes of Deforestation: Lessons from Economic Models. *The World Bank Research Observer,* **14,** 73-98.

Antunes, P., Santos, R. & Videira, N. (2006) Participatory decision making for sustainable development—the use of mediated modelling techniques. *Land Use Policy,* **23,** 44-52.

Arnold, J., Kohlin, G., Persson, R. & Shepherd, G. (2003) Fuelwood Revisited: What has changed in the last decade? CIFOR, Bogor, Indonesia.

Arnold, J.M. & Pérez, M.R. (2001) Can non-timber forest products match tropical forest conservation and development objectives? *Ecological economics,* **39,** 437-447.

Arrow, K., Solow, R., Portney, P.R., Leamer, E.E., Radner, R. & Schuman, H. (2001) Report of the NOAA Panel on Contingent Valuation. NOAA, USA.

Ashton, K. & Jones, C. (2013) Geographis of Human Wellbeing. pp. 44. Geography Teachers' Association of Victoria Inc.

Asiedu, E. (2002) On the Determinants of Foreign Direct Investment to Developing Countries: Is Africa Different? *World Development,* **30,** 107-119.

Asimakopoulos, D., Deligiorgi, D., Drakopoulos, C., Helmis, C., Kokkori, K., Lalas, D., Sikiotis, D. & Varotsos, C. (1992) An experimental study of nightime air-pollutant transport over complex terrain in Athens. *Atmospheric Environment. Part B. Urban Atmosphere,* **26,** 59-71.

Asselman, N.E.M., Middelkoop, H. & van Dijk, P.M. (2003) The impact of changes in climate and land use on soil erosion, transport and deposition of suspended sediment in the River Rhine. *Hydrological Processes,* **17,** 3225-3244.

Athanas, A. & Vorhies, F. (2001) Guidelines for financing protected areas in East Asia. IUCN.

Attiwill, P.M. & Adams, M.A. (1993) Nutrient cycling in forests. *New Phytologist,* **124,** 561-582.

Ayling, J. (2013) What Sustains Wildlife Crime? Rhino Horn Trading and the Resilience of Criminal Networks. *Journal of International Wildlife Law & Policy,* **16,** 57-80.

Aziz, A., Barlow, A.C.D., Greenwood, C.C. & Islam, A. (2013) Prioritizing threats to improve conservation strategy for the tiger Panthera tigris in the Sundarbans Reserve Forest of Bangladesh. *Oryx,* **47,** 510-518.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J. & Mathijs, E. (2008) Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems,* **98,** 147-155.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J. & Mathijs, E. (2009) The economic contribution of forest resource use to rural livelihoods in Tigray, Northern Ethiopia. *Forest Policy and Economics,* **11,** 109-117.

Baird, I.G. & Dearden, P. (2003) Biodiversity Conservation and Resource Tenure Regimes: A Case Study from Northeast Cambodia. *Environmental Management,* **32,** 541-550.

Baja-Lapis, A. (2009) Specialty rattans of the ASEAN. *Blumea-Biodiversity, Evolution and Biogeography of Plants,* **54,** 39-43.

Baker, R. & Ruting, B. (2014) Environmental policy analysis: a guide to non-market valuation. *Productivity Commission Canberra*.

Balick, M.J. & Mendelsohn, R. (1992) Assessing the Economic Value of Traditional Medicines from Tropical Rain-Forests. *Conservation Biology,* **6,** 128-130.

Ballantyne, R., Packer, J. & Sutherland, L.A. (2011) Visitors' memories of wildlife tourism: Implications for the design of powerful interpretive experiences. *Tourism Management,* **32,** 770-779.

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K. & Turner, R.K. (2002) Economic Reasons for Conserving Wild Nature. *Science,* **297,** 950-953.

Balvanera, P., Pfisterer, A.B., Buchmann, N., He, J.S., Nakashizuka, T., Raffaelli, D. & Schmid, B. (2006) Quantifying the evidence for biodiversity effects on ecosystem functioning and services. *Ecol Lett,* **9,** 1146-56.

Baral, N., Stern, M.J. & Bhattarai, R. (2008) Contingent valuation of ecotourism in Annapurna conservation area, Nepal: Implications for sustainable park finance and local development. *Ecological Economics,* **66,** 218-227.

Bardgett, R.D. & Wardle, D.A. (2003) Herbivore-mediated linkages between aboveground and belowground communities. *Ecology,* **84,** 2258-2268.

Barlow, A.C., Greenwood, C.J., Ahmad, I.U. & Smith, J.L. (2010) Use of an Action-Selection Framework for Human-Carnivore Conflict in the Bangladesh Sundarbans. *Conservation Biology,* **24,** 1338-1347.

Barnett, J. & Adger, W.N. (2007) Climate change, human security and violent conflict. *Political Geography,* **26,** 639-655.

Barraclough, S. & Ghimire, K. (1995) *Forests and livelihoods: the social dynamics of deforestation in developing countries.* Springer.

Barrena, J., Nahuelhual, L., Báez, A., Schiappacasse, I. & Cerda, C. (2014) Valuing cultural ecosystem services: Agricultural heritage in Chiloé island, southern Chile. *Ecosystem Services,* **7,** 66-75.

Barrett, C.B. & Arcese, P. (1995) Are Integrated Conservation-Development Projects (ICDPs) Sustainable? On the conservation of large mammals in sub-Saharan Africa. *World Development,* **23,** 1073-1084.

Barrett, C.B., Clark, M.B., Clay, D.C. & Reardon, T. (2005) Heterogeneous constraints, incentives and income diversification strategies in rural Africa. *Quarterly journal of international agriculture,* **44,** 37-60.

Barrett, C.B., Reardon, T. & Webb, P. (2001) Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy,* **26,** 315-331.

Barua, P., Chakraborty, S., Das, J., Sen, S., Barua, P., Chakraborty, S., Das, J. & Sen, S. (2012) Fishing industry and fisherfolk existence through microcredit services for India and Bangladesh. *Bangladesh Research Publications Journal,* **7,** 36-45.

Bawa, K.S. (2006) Globally Dispersed Local Challenges in Conservation Biology. *Conservation Biology,* **20,** 696-699.

Baynes, J., Herbohn, J., Smith, C., Fisher, R. & Bray, D. (2015) Key factors which influence the success of community forestry in developing countries. *Global Environmental Change,* **35,** 226-238.

Beall, J. (2001) Valuing Social Resources or Capitalizing on Them? Limits to Pro-poor Urban Governance in Nine Cities of the South. *International Planning Studies,* **6,** 357-375.

Bebbington, A. (1999) Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty. *World Development,* **27,** 2021-2044.

Beck, T. & Madan, G.G. (2000) Common Property Resources and the Poor: Findings from West Bengal. *Economic and Political Weekly,* **35,** 147-153.

Beckett, K.P., Freer-Smith, P. & Taylor, G. (1998) Urban woodlands: their role in reducing the effects of particulate pollution. *Environmental pollution,* **99,** 347-360.

Berkes, F. (2004) Rethinking Community-Based Conservation. *Conservation Biology,* **18,** 621-630.

Berkes, F. (2012) *Sacred ecology.* Routledge.

Berry, S. (1989) Social institutions and access to resources. *Africa,* **59,** 41-55.

Betts, R.A., Cox, P.M., Collins, M., Harris, P.P., Huntingford, C. & Jones, C.D. (2004) The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming. *Theoretical and Applied Climatology,* **78**.

Bhandari, P.B. (2013) Rural livelihood change? Household capital, community resources and livelihood transition. *Journal of Rural Studies,* **32,** 126-136.

Biao, Z., Wenhua, L., Gaodi, X. & Yu, X. (2010) Water conservation of forest ecosystem in Beijing and its value. *Ecological Economics,* **69,** 1416-1426.

Biesmeijer, J.C., Roberts, S.P.M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A.P., Potts, S.G., Kleukers, R., Thomas, C.D., Settele, J. & Kunin, W.E. (2006) Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. *Science,* **313,** 351-354.

Billon, P.L. (2002) Logging in Muddy Waters: The Politics of Forest Exploitation in Cambodia. *Critical Asian Studies,* **34,** 563-586.

Bils, M. & Klenow, P.J. (2000) Does Schooling Cause Growth? *The American Economic Review,* **90,** 1160-1183.

Bingham, G., Bishop, R., Brody, M., Bromley, D., Clark, E., Cooper, W., Costanza, R., Hale, T., Hayden, G., Kellert, S., Norgaard, R., Norton, B., Payne, J., Russell, C. & Suter, G. (1995) Issues in ecosystem valuation: improving information for decision making. *Ecological Economics,* **14,** 73-90.

Blanchflower, D.G. & Oswald, A.J. (2004) Well-being over time in Britain and the USA. *Journal of public economics,* **88,** 1359-1386.

Bochet, E., Rubio, J.L. & Poesen, J. (1998) Relative efficiency of three representative matorral species in reducing water erosion at the microscale in a semi-arid climate (Valencia, Spain). *Geomorphology,* **23,** 139-150.

Bookbinder, M.P., Dinerstein, E., Rijal, A., Cauley, H. & Rajouria, A. (1998) Ecotourism's Support of Biodiversity Conservation. *Conservation Biology,* **12,** 1399-1404.

Boon, E. (2013) Assessing Climate Change Impacts on Ecosystem Services and Livelihoods in Ghana: Case Study of Communities around Sui Forest Reserve. *Journal of Ecosystem & Ecography,* **03**.

Botkin, D.B. & Beveridge, C.E. (1997) Cities as environments. *Urban Ecosystems,* **1,** 3-19.

Boyd, E., Gutierrez, M. & Chang, M. (2007) Small-scale forest carbon projects: Adapting CDM to low-income communities. *Global Environmental Change,* **17,** 250-259.

Boyd, J. & Banzhaf, S. (2007) What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics,* **63,** 616-626.

Brander, L., Brouwer, R. & Wagtendonk, A. (2013) Economic valuation of regulating services provided by wetlands in agricultural landscapes: A meta-analysis. *Ecological Engineering,* **56,** 89-96.

Brechin, S.R., Fortwangler, C.L., Wilshusen, P.R. & West, P.C. (2003) *Contested nature: promoting international biodiversity with social justice in the twenty-first century.* Suny Press.

Briceno-Garmendia, C., Estache, A. & Shafik, N. (2004) Infrastructure services in developing countries: access, quality, costs, and policy reform.

Brosius, J.P. & Russell, D. (2003) Conservation from AboveImposing Transboundary Conservation. *Journal of Sustainable Forestry,* **17,** 39-65.

Burgess, J.C. (1993) Timber production, timber trade and tropical deforestation. *Ambio,* 136-143.

Burgos, S. & Ear, S. (2010) China's Strategic Interests in Cambodia: Influence and Resources. *Asian Survey,* **50,** 615-639.

Byers, B.A., Cunliffe, R.N. & Hudak, A.T. (2001) Linking the Conservation of Culture and Nature: A Case Study of Sacred Forests in Zimbabwe. *Human Ecology,* **29,** 187-218.

Byron, N. & Arnold, M. (1999) What Futures for the People of the Tropical Forests? *World Development,* **27,** 789-805.

Cadotte, M.W., Cardinale, B.J. & Oakley, T.H. (2008) Evolutionary history and the effect of biodiversity on plant productivity. *Proc Natl Acad Sci U S A,* **105,** 17012-7.

Cai, H., Henderson, J.V. & Zhang, Q. (2013) China's land market auctions: evidence of corruption? *The RAND Journal of Economics,* **44,** 488-521.

Calder, I.R. (2007) Forests and water—Ensuring forest benefits outweigh water costs. *Forest Ecology and Management,* **251,** 110-120.

Campbell, L.M. (1999) Ecotourism in rural developing communities. *Annals of Tourism Research,* **26,** 534-553.

Cao, M., Zou, X., Warren, M. & Zhu, H. (2006) Tropical Forests of Xishuangbanna, China1. *Biotropica,* **38,** 306-309.

Caplan, A.J., Grijalva, T.C. & Jakus, P.M. (2002) Waste not or want not? A contingent ranking analysis of curbside waste disposal options. *Ecological Economics,* **43,** 185-197.

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S. & Naeem, S. (2012) Biodiversity loss and its impact on humanity. *Nature,* **486,** 59-67.

Cardinale, B.J., Matulich, K.L., Hooper, D.U., Byrnes, J.E., Duffy, E., Gamfeldt, L., Balvanera, P., O'Connor, M.I. & Gonzalez, A. (2011) The functional role of producer diversity in ecosystems. *Am J Bot,* **98,** 572-92.

Cardinale, B.J., Srivastava, D.S., Duffy, J.E., Wright, J.P., Downing, A.L., Sankaran, M. & Jouseau, C. (2006) Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature,* **443,** 989-92.

Cardinale, B.J., Wright, J.P., Cadotte, M.W., Carroll, I.T., Hector, A., Srivastava, D.S., Loreau, M. & Weis, J.J. (2007) Impacts of plant diversity on biomass production increase through time because of species complementarity. *Proc Natl Acad Sci U S A,* **104,** 18123-8.

Carpenter, J.P., Daniere, A.G. & Takahashi, L.M. (2004) Cooperation, trust, and social capital in Southeast Asian urban slums. *Journal of Economic Behavior & Organization,* **55,** 533-551.

Carreño, L., Frank, F.C. & Viglizzo, E.F. (2012) Tradeoffs between economic and ecosystem services in Argentina during 50 years of land-use change. *Agriculture, Ecosystems & Environment,* **154,** 68-77.

Carson, R., Flores, N. & Meade, N. (2001) Contingent Valuation: Controversies and Evidence. *Environmental and Resource Economics,* **19,** 173-210.

Carter, T.S. (1996) The failure of environmental regulation in New York. *Crime, Law and Social Change,* **26,** 27-52.

Cattell, V. (2001) Poor people, poor places, and poor health: the mediating role of social networks and social capital. *Social Science & Medicine,* **52,** 1501-1516.

Cerutti, P.O., Tacconi, L., Lescuyer, G. & Nasi, R. (2013) Cameroon's hidden harvest: Commercial chainsaw logging, corruption, and livelihoods. *Society & Natural Resources,* **26,** 539-553.

Chan, S., Crosby, M.J., Islam, M.Z. & Tordoff, A.W. (2004) Important Bird Areas in Asia: Key Sites for Conservation. BirdLife International.

Chapin, F.S., Randerson, J.T., McGuire, A.D., Foley, J.A. & Field, C.B. (2008) Changing feedbacks in the climate–biosphere system. *Frontiers in Ecology and the Environment,* **6,** 313-320.

Chen, T.-M., Kuschner, W.G., Gokhale, J. & Shofer, S. (2007) Outdoor Air Pollution: Nitrogen Dioxide, Sulfur Dioxide, and Carbon Monoxide Health Effects. *The American Journal of the Medical Sciences,* **333,** 249-256.

Choudhury, K. (2001) The Bangladesh Sundarbans : a photoreal sojourn. IUCN, Dhaka, Bangladesh.

Cinner, J.E., Daw, T. & McClanahan, T.R. (2009) Socioeconomic Factors that Affect Artisanal Fishers' Readiness to Exit a Declining Fishery *Conservation Biology,* **23,** 124-130.

Cleaver, F. (2005) The inequality of social capital and the reproduction of chronic poverty. *World Development,* **33,** 893-906.

Clements, T. (2010) Reduced Expectations: the political and institutional challenges of REDD+. *Oryx,* **44,** 309-310.

Corbera, E., Kosoy, N. & Martínez Tuna, M. (2007) Equity implications of marketing ecosystem services in protected areas and rural communities: Case studies from Meso-America. *Global Environmental Change,* **17,** 365-380.

Costanza, R. (2000) Social Goals and the Valuation of Ecosystem Services. *Ecosystems,* **3,** 4-10.

Costanza, R. (2006) Nature: ecosystems without commodifying them. *Nature,* **443,** 749-749.

Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. & van den Belt, M. (1997) The value of the world's ecosystem services and natural capital. *Nature,* **387,** 253-260.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S. & Turner, R.K. (2014) Changes in the global value of ecosystem services. *Global Environmental Change,* **26,** 152-158.

Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L., Boumans, R., Danigelis, N.L., Dickinson, J., Elliott, C., Farley, J., Gayer, D.E., Glenn, L.M., Hudspeth, T., Mahoney, D., McCahill, L., McIntosh, B., Reed, B., Rizvi, S.A.T., Rizzo, D.M., Simpatico, T. & Snapp, R. (2007) Quality of life: An approach integrating opportunities, human needs, and subjective well-being. *Ecological Economics,* **61,** 267-276.

Costanza, R., Kubiszewski, I., Ervin, D., Bluffstone, R., Boyd, J., Brown, D., Chang, H., Dujon, V., Granek, E., Polasky, S., Shandas, V. & Yeakley, A. (2011) Valuing ecological systems and services. *F1000 Biol Rep,* **3,** 14.

Costanza, R., Pérez-Maqueo, O., Martinez, M.L., Sutton, P., Anderson, S.J. & Mulder, K. (2008) The Value of Coastal Wetlands for Hurricane Protection. *AMBIO: A Journal of the Human Environment,* **37,** 241-248.

Cousins, B. (1996) Conflict Management for Multiple Resource Users in Pastoralist and Agro-Pastoralist Contexts. *IDS Bulletin,* **27,** 41-54.

Craney, T.A. & Surles, J.G. (2002) Model-Dependent Variance Inflation Factor Cutoff Values. *Quality Engineering,* **14,** 391-403.

Creedy, J. & Wurzbacher, A.D. (2001) The economic value of a forested catchment with timber, water and carbon sequestration benefits. *Ecological Economics,* **38,** 71-83.

Critical Ecosystem Partnership Fund (2012) Ecosystem Profile: Indo-Burma Biodiversity Hotspot 2011 Update. Critical Ecosystem Partnership Fund.

Croxford, B., Penn, A. & Hillier, B. (1996) Spatial distribution of urban pollution: civilizing urban traffic. *Science of The Total Environment,* **189,** 3-9.

Cruz, W., Arocena-Francisco, H. & Tapawan, Z.G. (1988) *The on-site and downstream costs of soil erosion in the Magat and Pantabangan watersheds.* College of Economics and Management, University of the Philippines at Los Baños.

Csorba, G., Son, N.T., Saveng, I. & Furey, N.M. (2011) Revealing cryptic bat diversity: three new Murina and redescription of M. tubinaris from Southeast Asia. *Journal of Mammalogy,* **92,** 891-904.

Cummins, R.A., Eckersley, R., Pallant, J., van Vugt, J. & Misajon, R. (2003) Developing a National Index of Subjective Wellbeing: The Australian Unity Wellbeing Index. *Social Indicators Research,* **64,** 159-190.

Daily, G. (1997) *Nature's services: societal dependence on natural ecosystems.* Island Press.

Daily, G.C., Polasky, S., Goldstein, J., Kareiva, P.M., Mooney, H.A., Pejchar, L., Ricketts, T.H., Salzman, J. & Shallenberger, R. (2009) Ecosystem services in decision making: time to deliver. *Frontiers in Ecology and the Environment,* **7,** 21-28.

Daniel, T.C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J.W., Chan, K.M., Costanza, R., Elmqvist, T., Flint, C.G. & Gobster, P.H. (2012) Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences,* **109,** 8812-8819.

Davis, K.F., Yu, K., Rulli, M.C., Pichdara, L. & D/'Odorico, P. (2015) Accelerated deforestation driven by large-scale land acquisitions in Cambodia. *Nature Geosci,* **8,** 772-775.

Daw, T.I.M., Brown, K., Rosendo, S. & Pomeroy, R. (2011) Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. *Environmental Conservation,* **38,** 370-379.

de Groot, R. (2006) Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landscape and Urban Planning*, **75,** 175-186.

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A., Portela, R., Rodriguez, L.C., ten Brink, P. & van Beukering, P. (2012) Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services,* **1,** 50-61.

de Groot, R.S., Wilson, M.A. & Boumans, R.M.J. (2002) A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics,* **41,** 393-408.

De Jong, B.H.J., Tipper, R. & Montoya-Gómez, G. (2000) An economic analysis of the potential for carbon sequestration by forests: evidence from southern Mexico. *Ecological Economics,* **33,** 313-327.

De Lopez, T.T. (2001) Deforestation in Cambodia: a stakeholder management approach. *International Journal of Sustainable Development & World Ecology,* **8,** 380-394.

Deacon, R.T., Kolstad, C.D., Kneese, A.V., Brookshire, D.S., Scrogin, D., Fisher, A.C., Ward, M., Smith, K. & Wilen, J. (1998) Research Trends and Opportunities in Environmental and Natural Resource Economics. *Environmental and Resource Economics,* **11,** 383-397.

Deb, A.K. (1998) Fake blue revolution: environmental and socio-economic impacts of shrimp culture in the coastal areas of Bangladesh. *Ocean & Coastal Management,* **41,** 63-88.

DeFries, R.S., Foley, J.A. & Asner, G.P. (2004) Land-use choices: Balancing human needs and ecosystem function. *Frontiers in Ecology and the Environment,* **2,** 249-257.

deGroot, R.S., Alkemade, R., Braat, L., Hein, L. & Willemen, L. (2010) Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity,* **7,** 260-272.

Dercon, S. (2004) Growth and shocks: evidence from rural Ethiopia. *Journal of Development Economics,* **74,** 309-329.

Deshingkar, P., Farrington, J., Rao, L., Akter, S., Sharma, P., Freeman, H. & Reddy, J. (2008) Livestock and poverty reduction in India: findings from the ODI Livelihood Options Project.

Dewi, S., Belcher, B. & Puntodewo, A. (2005) Village economic opportunity, forest dependence, and rural livelihoods in East Kalimantan, Indonesia. *World Development,* **33,** 1419-1434.

DFID (1999) Sustaianble livelihoods guidance sheets UK.

Ding, H. & Nunes, P.A.L.D. (2014) Modeling the links between biodiversity, ecosystem services and human wellbeing in the context of climate change: Results from an

econometric analysis of the European forest ecosystems. *Ecological Economics,* **97,** 60-73.

Dodds, W.B. (1991) In search of value: how price and store name information influence buyers′ product perceptions. *Journal of Consumer Marketing,* **8,** 15-24.

Dolan, P. & Metcalfe, R. (2012) Measuring subjective wellbeing: Recommendations on measures for use by national governments. *Journal of social policy,* **41,** 409-427.

Dorren, L.K.A., Berger, F., Imeson, A.C., Maier, B. & Rey, F. (2004) Integrity, stability and management of protection forests in the European Alps. *Forest Ecology and Management,* **195,** 165-176.

Dorward, A., Poole, N., Morrison, J., Kydd, J. & Urey, I. (2003) Markets, institutions and technology: missing links in livelihoods analysis. *Development policy review,* **21,** 319-332.

Dranove, D. (2012) Practical regression: Building your model- What variable to include (ed N. University). Kellogg Case Publishing USA.

Dressler, W.H. & McDermott, M.H. (2010) Indigenous Peoples and Migrants: Social Categories, Rights, and Policies for Protected Areas in the Philippine Uplands. *Journal of Sustainable Forestry,* **29,** 328-361.

Dudley, N. & Stolton, S. (2003) Running pure: the importance of forest protected areas to drinking water. *World Bank Publications*.

Eames, J.C. & Robson, C.R. (1993) Threatened primates in southern Vietnam. *Oryx,* **27,** 146-154.

Ebeling, J. & Yasué, M. (2009) The effectiveness of market-based conservation in the tropics: Forest certification in Ecuador and Bolivia. *Journal of Environmental Management,* **90,** 1145-1153.

Edmunds, D. & Wollenberg, E. (2001) A Strategic Approach to Multistakeholder Negotiations. *Development and Change,* **32,** 231-253.

Ellis, F. & Allison, E. (2004) Livelihood diversification and natural resource access. *Overseas Development Group, University of East Anglia*.

Emerton, L., Kekulandala, L.D.C.B., Regional Environmental Economics, P. & Lanka, I.S. (2003) *Assessment of the economic value of Muthurajawela wetland.* IUCN, Sri Lanka, Colombo.

Ezebilo, E.E. & Mattsson, L. (2010) Socio-economic benefits of protected areas as perceived by local people around Cross River National Park, Nigeria. *Forest Policy and Economics*, **12,** 189-193.

Fa, J.E., Currie, D. & Meeuwig, J. (2003) Bushmeat and food security in the Congo Basin: linkages between wildlife and people's future. *Environmental Conservation,* **30,** 71-78.

Fairbrother, M. (2013) Rich People, Poor People, and Environmental Concern: Evidence across Nations and Time. *European Sociological Review,* **29,** 910-922.

FAO, IFAD & WFP (2015) The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. FAO, Rome.

Farrington, J. & Farrington, C. (2005) Rural accessibility, social inclusion and social justice: towards conceptualisation. *Journal of Transport Geography,* **13,** 1-12.

Feder, G., Just, R.E. & Zilberman, D. (1985) Adoption of Agricultural Innovations in Developing Countries: A Survey. *Economic Development and Cultural Change,* **33,** 255-298.

Ferraro, P.J., Lawlor, K., Mullan, K.L. & Pattanayak, S.K. (2011) Forest Figures: Ecosystem Services Valuation and Policy Evaluation in Developing Countries. *Review of Environmental Economics and Policy,* **6,** 20-44.

Fish, R., Burgess, J., Chilvers, J., Footitt, A., Haines-Young, R., Russel, D., Turner, K. & Winter, D. (2011) Participatory and deliberative techniques to embed an ecosystems approach into decision making: An introductory guide.

Fisher, B., Turner, K., Zylstra, M., Brouwer, R., de Groot, R., Farber, S., Ferraro, P., Green, R., Hadley, D., Harlow, J., Jefferiss, P., Kirkby, C., Morling, P., Mowatt, S., Naidoo, R., Paavola, J., Strassburg, B., Yu, D. & Balmford, A. (2008) Ecosystem services and economic theory: integration for policy-relevant research. *Ecological Applications,* **18,** 2050-2067.

Fisher, B., Turner, R.K. & Morling, P. (2009) Defining and classifying ecosystem services for decision making. *Ecological Economics,* **68,** 643-653.

Fisher, J.A., Patenaude, G., Giri, K., Lewis, K., Meir, P., Pinho, P., Rounsevell, M.D.A. & Williams, M. (2014) Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. *Ecosystem Services,* **7,** 34-45.

Fisher, J.A., Patenaude, G., Meir, P., Nightingale, A.J., Rounsevell, M.D.A., Williams, M. & Woodhouse, I.H. (2013) Strengthening conceptual foundations: Analysing frameworks for ecosystem services and poverty alleviation research. *Global Environmental Change,* **23,** 1098-1111.

Flohr, C., Tuyen, L.N., Lewis, S., Quinnell, R., Minh, T.T., Liem, H.T., Campbell, J., Pritchard, D., Hien, T.T., Farrar, J., Williams, H. & Britton, J. (2006) Poor sanitation and helminth infection protect against skin sensitization in Vietnamese children: A cross-sectional study. *Journal of Allergy and Clinical Immunology,* **118,** 1305-1311.

Flyman, M.V. & Afolayan, A.J. (2006) The suitability of wild vegetables for alleviating human dietary deficiencies. *South African Journal of Botany*, **72,** 492-497.

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S. & Walker, B. (2002) Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment,* **31,** 437-440.

Forest Department (2017) http://www.bforest.gov.bd/site/page/24dbd743-10f0-4c79-8bb9-14cc12c269a4/Map-showing-forest-types-and-location.

Foster, V. & Mourato, S. (2002) Testing for Consistency in Contingent Ranking Experiments. *Journal of Environmental Economics and Management,* **44,** 309-328.

Frechette, J. (2014) *Constructing and experimentally testing the impacts of animal-generated dispersal kernels in a north-eastern Cambodian fruiting tree*. PhD, The University of Florida, Florida, USA.

Freer-Smith, P., Holloway, S. & Goodman, A. (1997) The uptake of particulates by an urban woodland: site description and particulate composition. *Environmental Pollution,* **95,** 27-35.

Frewer, T. & Chan, S. (2014) GIS and the 'Usual Suspects'-[Mis]understanding Land Use Change in Cambodia. *Human Ecology,* **42,** 267-281.

Fritschen, L.J. & Edmonds, R. (1976) Dispersion of fluorescent particles into and within a douglas fir forest. . *In: Symposium on Atmosphere- Surface Exchange of Particulate and Gaseous Pollutants. Energy Research & Development Administrative Symposium Series* USA.

Fu, B.-J., Su, C.-H., Wei, Y.-P., Willett, I.R., Lü, Y.-H. & Liu, G.-H. (2010) Double counting in ecosystem services valuation: causes and countermeasures. *Ecological Research,* **26,** 1-14.

Gallai, N., Salles, J.-M., Settele, J. & Vaissière, B.E. (2009) Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics,* **68,** 810-821.

Gamfeldt, L., Snäll, T., Bagchi, R., Jonsson, M., Gustafsson, L., Kjellander, P., Ruiz-Jaen, M.C., Fröberg, M., Stendahl, J., Philipson, C.D., Mikusiński, G., Andersson, E., Westerlund, B., Andrén, H., Moberg, F., Moen, J. & Bengtsson, J. (2013) Higher levels of multiple ecosystem services are found in forests with more tree species. *Nature Communications,* **4,** 1340.

Ganzeveld, L., Lelieveld, J., Dentener, F., Krol, M., Bouwman, A. & Roelofs, G.J. (2002) Global soil-biogenic NOx emissions and the role of canopy processes. *Journal of Geophysical Research: Atmospheres,* **107**.

Garrod, G. & Willis, K. (1998) Using Contingent Ranking to Estimate the Loss of Amenity Value for Inland Waterways from Public Utility Service Structures. *Environmental and Resource Economics,* **12,** 241-247.

Gaveau, D.L.A., Wandono, H. & Setiabudi, F. (2007) Three decades of deforestation in southwest Sumatra: Have protected areas halted forest loss and logging, and promoted re-growth? *Biological Conservation,* **134,** 495-504.

Geissler, P., Hartmann, T. & Neang, T. (2012) A new species of the genus Lygosoma Hardwicke & Gray, 1827 (Squamata: Scincidae) from northeastern Cambodia, with an updated identification key to the genus Lygosoma in mainland Southeast Asia. *Zootaxa,* **3190,** 5.

Getzner, M. & Islam, M.S. (2013) Natural resources, livelihoods, and reserve management: a case study from Sundarbans mangrove forests, Bangladesh. *International Journal of Sustainable Development and Planning,* **8,** 75-87.

Ghate, R., Mehra, D. & Nagendra, H. (2009) Local institutions as mediators of the impact of markets on non-timber forest product extraction in central India. *Environmental Conservation,* **36,** 51-61.

Giddings, B., Hopwood, B. & O'Brien, G. (2002) Environment, economy and society: fitting them together into sustainable development. *Sustainable Development,* **10,** 187-196.

Gifford-Gonzalez, D. (1998) Early Pastoralists in East Africa: Ecological and Social Dimensions. *Journal of Anthropological Archaeology,* **17,** 166-200.

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T., Masek, J. & Duke, N. (2011) Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography,* **20,** 154-159.

Gleick, P.H. (1998) Water in Crisis: Paths to Sustainable Water Use. *Ecological Applications,* **8,** 571-579.

Godlee, F. (2015) Medical corruption in the UK. *BMJ : British Medical Journal,* **350**.

Godoy, R., O'Neill, K., Groff, S., Kostishack, P., Cubas, A., Demmer, J., McSweeney, K., Overman, J., Wilkie, D., Brokaw, N. & Martínez, M. (1997) Household determinants of deforestation by amerindians in honduras. *World Development,* **25,** 977-987.

Gómez-Baggethun, E., de Groot, R., Lomas, P.L. & Montes, C. (2010) The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics,* **69,** 1209-1218.

Gracey, M., Williams, P. & Houston, S. (1997) Environmental health conditions in remote and rural Aboriginal communities in Western Australia. *Australian and New Zealand Journal of Public Health,* **21,** 511-518.

Grant, S.L., Tamason, C.C., Hoque, B.A. & Jensen, P.K.M. (2015) Drinking cholera: salinity levels and palatability of drinking water in coastal Bangladesh. *Tropical Medicine & International Health,* **20,** 455-461.

Grootaert, C. (1999) Social capital, household welfare, and poverty in Indonesia.

Gruzen, R., Benoit, G., Gentry, B., Smith, M.M. & Brennan-Galvin, E. (2006) Shrimp aquaculture and urban growth in Madagascar: sustaining societies and conserving coasts. *Rapport en management de l'environnement. Université de Yale, New Haven, 23p*.

Gunter, T.D. (2015) *Four methods for combining dependent effects from studies reporting regression analysis*. The Florida State University.

Guo, Z., Xiao, X. & Li, D. (2000) AN ASSESSMENT OF ECOSYSTEM SERVICES: WATER FLOW REGULATION AND HYDROELECTRIC POWER PRODUCTION. *Ecological Applications,* **10,** 925-936.

Gupta, A. & Siebert, U. (2004) Combating Forest Corruption. *Journal of Sustainable Forestry,* **19,** 337-349.

Hagihara, K. & Asahi, C. (2016) Sustainability and Human Well-Being. *Coping with Regional Vulnerability: Preventing and Mitigating Damages from Environmental Disasters* (eds K. Hagihara & C. Asahi), pp. 3-19. Springer Japan, Tokyo.

Hagihara, K., Asahi, C. & Ahmed, T. (2016) *Coping with regional vulnerability.* Springer.

Hailu, G., Boxall, P.C. & McFarlane, B.L. (2005) The influence of place attachment on recreation demand. *Journal of Economic Psychology,* **26,** 581-598.

Hajjar, R. & Hodgkin, T. (2007) The use of wild relatives in crop improvement: a survey of developments over the last 20 years. *Euphytica*, **156,** 1-13.

Hamelin, A.-M., Habicht, J.-P. & Beaudry, M. (1999) Food Insecurity: Consequences for the Household and Broader Social Implications. *The Journal of Nutrition,* **129,** 525.

Hanley, N., Mourato, S. & Wright, R.E. (2001) Choice Modelling Approaches: A Superior Alternative for Environmental Valuatioin? *Journal of Economic Surveys,* **15,** 435-462.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O. & Townshend, J.R.G. (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science,* **342,** 850-853.

He, G., Chen, X., Liu, W., Bearer, S., Zhou, S., Cheng, L.Y., Zhang, H., Ouyang, Z. & Liu, J. (2008) Distribution of economic benefits from ecotourism: a case study of Wolong Nature Reserve For Giant Pandas in China. *Environ Manage,* **42,** 1017-25.

Hecht, S., Yang, A.L., Basnett, B.S., Padoch, C. & Peluso, N.L. (2015) *People in motion, forests in transition: trends in migration, urbanization, and remittances and their effects on tropical forests.* CIFOR.

Hedges, L.V. & Olkin, I. (2014) *Statistical methods for meta-analysis.* Academic press.

Hein, L., van Koppen, K., de Groot, R.S. & van Ierland, E.C. (2006) Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics,* **57,** 209-228.

Henley, W., Patterson, M., Neves, R. & Lemly, A.D. (2000) Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. *reviews in Fisheries Science,* **8,** 125-139.

Herrero, M., Thornton, P.K., Notenbaert, A.M.O., Msangi, S., Wood, S., Kruska, R., Dixon, J.A., Bossio, D.A., van de Steeg, J. & Freeman, H. (2012) Drivers of change in crop–livestock systems and their potential impacts on agro-ecosystems services and human wellbeing to 2030: A study commissioned by the CGIAR Systemwide Livestock Programme.

Hill, J. (2011) Review of local knowledge and uses for primates in the Veun Sai-Siem Pang Conservation Area, Northeastern Cambodia. *Canopy,* **12,** 9-10.

Hillring, B. (2006) World trade in forest products and wood fuel. *Biomass and Bioenergy,* **30,** 815-825.

Hogarth, N.J., Belcher, B., Campbell, B. & Stacey, N. (2013) The Role of Forest-Related Income in Household Economies and Rural Livelihoods in the Border-Region of Southern China. *World Development,* **43,** 111-123.

Holifield Collins, C.D., Stone, J.J. & Cratic, L. (2015) Runoff and sediment yield relationships with soil aggregate stability for a state-and-transition model in southeastern Arizona. *Journal of Arid Environments,* **117,** 96-103.

Holmes, G. (2010) The Rich, the Powerful and the Endangered: Conservation Elites, Networks and the Dominican Republic. *Antipode,* **42,** 624-646.

Home, R., Keller, C., Nagel, P., Bauer, N. & Hunziker, M. (2009) Selection criteria for flagship species by conservation organizations. *Environmental Conservation,* **36,** 139-148.

Hooper, D.U. & Vitousek, P.M. (1998) Effects of Plant Composition and Diversity on Nutrient Cycling. *Ecological Monographs,* **68,** 121-149.

Hopwood, B., Mellor, M. & O'Brien, G. (2005) Sustainable development: mapping different approaches. *Sustainable Development,* **13,** 38-52.

Hoq, M.E. (2007) An analysis of fisheries exploitation and management practices in Sundarbans mangrove ecosystem, Bangladesh. *Ocean & Coastal Management,* **50,** 411-427.

Hossain, M.A., Thompson, B.S., ChowdHury, G.W., Mohsanin, S., Fahad, Z.H., Koldewey, H.J. & Islam, M.A. (2015) Sawfish exploitation and status in Bangladesh. *Aquatic Conservation: Marine and Freshwater Ecosystems,* **25,** 781-799.

Howarth, R.B. & Wilson, M.A. (2006) A Theoretical Approach to Deliberative Valuation: Aggregation by Mutual Consent. *Land Economics,* **82,** 1-16.

Hua, X., Yan, J. & Zhang, Y. (2017) Evaluating the role of livelihood assets in suitable livelihood strategies: Protocol for anti-poverty policy in the Eastern Tibetan Plateau, China. *Ecological Indicators,* **78,** 62-74.

Huai, K.H.-Y. & Pei, S.-J. (2000) Wild plants in the diet of Arhorchin Mongol herdsmen in Inner Mongolia. *Economic botany,* **54,** 528-536.

Huang, C.-H. & Kronrad, G.D. (2001) The cost of sequestering carbon on private forest lands. *Forest Policy and Economics,* **2,** 133-142.

Hughes, L. (2000) Biological consequences of global warming: is the signal already apparent? *Trends in Ecology & Evolution,* **15,** 56-61.

Hundecha, Y. & Bárdossy, A. (2004) Modeling of the effect of land use changes on the runoff generation of a river basin through parameter regionalization of a watershed model. *Journal of Hydrology,* **292,** 281-295.

Hutton, J.M. & Leader-Williams, N. (2003) Sustainable use and incentive-driven conservation: realigning human and conservation interests. *Oryx,* **37,** 215-226.

Iftekhar, M. & Islam, M. (2004a) Degeneration of Bangladesh's Sundarbans mangroves: a management issue. *International Forestry Review,* **6,** 123-135.

Iftekhar, M. & Islam, M. (2004b) Managing mangroves in Bangladesh: A strategy analysis. *Journal of Coastal Conservation,* **10,** 139-146.

Inskip, C., Ridout, M., Fahad, Z., Tully, R., Barlow, A., Barlow, C.G., Islam, M.A., Roberts, T. & MacMillan, D. (2013) Human–Tiger Conflict in Context: Risks to Lives and Livelihoods in the Bangladesh Sundarbans. *Human Ecology,* **41,** 169-186.

International Resources Group (2010) Intigrated resources managemnt plans for the Sundarbans (2010-2020). USDA, Washington DC, USA.

IPCC (2000) *Land Use, Land-Use Change, and Forestry.* Cambridge University Press.

Islam, M.M., Sallu, S., Hubacek, K. & Paavola, J. (2014) Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change,* **14,** 281-294.

Islam, S. (2003) Banglapedia. *National Encyclopedia, Asiatic Society of Bangladesh, Dhaka*.

Islam, S.N. & Gnauck, A. (2008) Mangrove wetland ecosystems in Ganges-Brahmaputra delta in Bangladesh. *Frontiers of Earth Science in China,* **2,** 439-448.

IUCN (2001) The economic value of East Africa's forests. IUCN - The World Conservation Union, Eastern Africa Regional Office, Nairobi, Kenya.

Iwasaki, S., Razafindrabe, B.H.N. & Shaw, R. (2009) Fishery livelihoods and adaptation to climate change: a case study of Chilika lagoon, India. *Mitigation and Adaptation Strategies for Global Change,* **14,** 339-355.

Jakobsen, J., Rasmussen, K., Leisz, S., Folving, R. & Quang, N.V. (2007) The effects of land tenure policy on rural livelihoods and food sufficiency in the upland village of Que, North Central Vietnam. *Agricultural Systems,* **94,** 309-319.

Jayne, T.S., Yamano, T., Weber, M.T., Tschirley, D., Benfica, R., Chapoto, A. & Zulu, B. (2003) Smallholder income and land distribution in Africa: implications for poverty reduction strategies. *Food Policy,* **28,** 253-275.

Jim, C.Y. & Chen, W.Y. (2010) External effects of neighbourhood parks and landscape elements on high-rise residential value. *Land Use Policy,* **27,** 662-670.

Johns, N. (1999) What is this thing called service? *European Journal of Marketing,* **33,** 958-974.

Johnson, A., Singh, S., Duangdala, M. & Hedemark, M. (2005) The western black crested gibbon Nomascus concolor in Laos: new records and conservation status. *Oryx,* **39,** 311-317.

Johnston, A. (2000) Indigenous Peoples and Ecotourism: Bringing Indigenous Knowledge and Rights into the Sustainability Equation. *Tourism Recreation Research,* **25,** 89-96.

Johnston, A. (2014) Indigenous Peoples and Ecotourism: Bringing Indigenous Knowledge and Rights into the Sustainability Equation. *Tourism Recreation Research,* **25,** 89-96.

Jokisch, B.D. (2002) Migration and Agricultural Change: The Case of Smallholder Agriculture in Highland Ecuador. *Human Ecology,* **30,** 523-550.

Kaewmahanin, J., Sukwong, S. & Fisher, R.J. (2008) Pred Nai Community Forest, Trad Province, Thailand. *Linking Conservation and Poverty Reduction*

Landscapes, People and Power (eds R. Fisher, S. Maginnis, W. Jackson, E. Barrow & S. Jeanrenaud), pp. 46-52. Earthscan, London, UK.

Kalaba, F.K., Quinn, C.H. & Dougill, A.J. (2013) The role of forest provisioning ecosystem services in coping with household stresses and shocks in Miombo woodlands, Zambia. *Ecosystem Services,* **5,** 143-148.

Kamanga, P., Vedeld, P. & Sjaastad, E. (2009) Forest incomes and rural livelihoods in Chiradzulu District, Malawi. *Ecological Economics,* **68,** 613-624.

Kar, S.P. & Jacobson, M.G. (2012) NTFP income contribution to household economy and related socio-economic factors: Lessons from Bangladesh. *Forest Policy and Economics,* **14,** 136-142.

Kemp, A.H. & Quintana, D.S. (2013) The relationship between mental and physical health: Insights from the study of heart rate variability. *International Journal of Psychophysiology,* **89,** 288-296.

Kerstetter, D.L., Hou, J.-S. & Lin, C.-H. (2004) Profiling Taiwanese ecotourists using a behavioral approach. *Tourism Management,* **25,** 491-498.

Kibria, A.G., Jashimuddin, M. & Makoto, I. (2014) Effects of participatory forest management on livelihood capitals of the community in Cox's Bazar, Bangladesh. *Journal of Forest Research,* **19,** 42-51.

Kibria, A.S.M.G., Inoue, M. & Nath, T.K. (2015) Analysing the land uses of forest-dwelling indigenous people in the Chittagong Hill Tracts, Bangladesh. *Agroforestry Systems,* **89,** 663-676.

Kibria, G. & Jashimuddin, M. (2012) Economic efficiency of land-use systems in the seasonally flooded areas of Comilla, Bangladesh. *Journal of Land Use Science,* **7,** 349-363.

Kim Phat, N., Knorr, W. & Kim, S. (2004) Appropriate measures for conservation of terrestrial carbon stocks—Analysis of trends of forest management in Southeast Asia. *Forest Ecology and Management,* **191,** 283-299.

Kim, S., Sasaki, N. & Koike, M. (2008) Assessment of non-timber forest products in Phnom Kok community forest, Cambodia. *Asia Europe Journal,* **6,** 345-354.

Kindermann, G., Obersteiner, M., Sohngen, B., Sathaye, J., Andrasko, K., Rametsteiner, E., Schlamadinger, B., Wunder, S. & Beach, R. (2008) Global cost estimates of reducing carbon emissions through avoided deforestation. *Proceedings of the National Academy of Sciences,* **105,** 10302-10307.

King, A., Behie, A., Hon, N. & Rawson, B. (2016) Patterns of salt lick use by mammals and birds in northeastern Cam. *Cambodian Journal of Natural History***,** 40.

King, B. (2011) Spatialising livelihoods: resource access and livelihood spaces in South Africa. *Transactions of the Institute of British Geographers,* **36,** 297-313.

Kinzig, A.P., Pacala, S.W. & Tilman, D. (2001) *The functional consequences of biodiversity: empirical progress and theoretical extensions.* Princeton University Press.

Kiss, A. (2004) Is community-based ecotourism a good use of biodiversity conservation funds? *Trends in Ecology & Evolution,* **19,** 232-237.

Klein, A.M., Vaissiere, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C. & Tscharntke, T. (2007) Importance of pollinators in changing landscapes for world crops. *Proc Biol Sci,* **274,** 303-13.

Koenig, J.Q., Larson, T.V., Hanley, Q.S., Rebolledo, V., Dumler, K., Checkoway, H., Wang, S., Lin, D. & Pierson, W.E. (1993) Pulmonary function changes in children associated with fine particulate matter. *Environmental Research,* **63,** 26-38.

Kubiszewski, I., Costanza, R., Paquet, P. & Halimi, S. (2013) Hydropower development in the lower Mekong basin: alternative approaches to deal with uncertainty. *Regional Environmental Change,* **13,** 3-15.

Kumar, P. (2010) *The economics of ecosystems and biodiversity: ecological and economic foundations.* UNEP/Earthprint.

Kuzilwa, J.A. (2005) The Role of Credit for Small Business Success. *The Journal of Entrepreneurship,* **14,** 131-161.

La Notte, A., D'Amato, D., Mäkinen, H., Paracchini, M.L., Liquete, C., Egoh, B., Geneletti, D. & Crossman, N.D. (2017) Ecosystem services classification: A systems ecology perspective of the cascade framework. *Ecological Indicators,* **74,** 392-402.

Larson, A.M., Cronkleton, P., Barry, D. & Pacheco, P. (2008) *Tenure Rights and Beyond: Community Access to Forest Resources in Latin America.* Center for International Forestry Research (CIFOR), Bogor, Indonesia.

Laurance, W.F. (1999) Reflections on the tropical deforestation crisis. *Biological Conservation,* **91,** 109-117.

Laurence, J. (2011) The Effect of Ethnic Diversity and Community Disadvantage on Social Cohesion: A Multi-Level Analysis of Social Capital and Interethnic Relations in UK Communities. *European Sociological Review,* **27,** 70-89.

Leach, M., Mearns, R. & Scoones, I. (1999) Environmental Entitlements: Dynamics and Institutions in Community-Based Natural Resource Management. *World Development,* **27,** 225-247.

Levy, D.E. & Lerch, P.B. (1991) Tourism as a Factor in Development Implications for Gender and Work in Barbados. *Gender and Society,* **5,** 67-85.

Lichter, D.T., Anderson, R.N. & Hayward, M.D. (1995) Marriage markets and marital choice. *Journal of Family Issues,* **16,** 412-431.

Linnell, J.D., Promberger, C., Boitani, L., Swenson, J.E., Breitenmoser, U. & Andersen, R. (2005) The linkage between conservation strategies for large carnivores and biodiversity: the view from the "half-full" forests of Europe. *Carnivorous animals and biodiversity: does conserving one save the other***,** 381-398.

Liston-Heyes, C. & Heyes, A. (1999) Recreational benefits from the Dartmoor National Park. *Journal of Environmental Management,* **55,** 69-80.

Liu, S. & Costanza, R. (2010) Ecosystem services valuation in China. *Ecological Economics,* **69,** 1387-1388.

Liu, X., Liu, B., Shishime, T., Yu, Q., Bi, J. & Fujitsuka, T. (2010) An empirical study on the driving mechanism of proactive corporate environmental management in China. *J Environ Manage,* **91,** 1707-17.

Liu, Z. & Liu, L. (2016) Characteristics and driving factors of rural livelihood transition in the east coastal region of China: a case study of suburban Shanghai. *Journal of Rural Studies,* **43,** 145-158.

Local Government Engineering Department (2017) http://www.lged.gov.bd/ViewMap2.aspx?DistrictID=39.

Lorenzo, A.B., Blanche, C.A., Qi, Y. & Guidry, M.M. (2000) Assessing reesidents' willingness to pay to preserve the community urban forest: a small-city case study. *Journal of Arboriculture and Urban Forestry,* **26,** 319-325.

Loucks, C., Mascia, M.B., Maxwell, A., Huy, K., Duong, K., Chea, N., Long, B., Cox, N. & Seng, T. (2009) Wildlife decline in Cambodia, 1953–2005: exploring the legacy of armed conflict. *Conservation Letters,* **2,** 82-92.

Lu, R. & Turco, R.P. (1995) Air pollutant transport in a coastal environment—II. Three-dimensional simulations over Los Angeles basin. *Atmospheric Environment,* **29,** 1499-1518.

Luo, Y., Liu, J. & Zhang, D. (2009) Role of traditional beliefs of Baima Tibetans in biodiversity conservation in China. *Forest Ecology and Management,* **257,** 1995-2001.

MacKerron, G. & Mourato, S. (2009) Life satisfaction and air quality in London. *Ecological Economics,* **68,** 1441-1453.

MacKinnon, K., Dudley, N. & Sandwith, T. (2011) Natural solutions: protected areas helping people to cope with climate change. *Oryx,* **45,** 461-462.

Mahar, G., Dhar, U., Rawal, R. & Bhatt, I. (2009) Implications of location specific data and their usefulness in conservation planning: an example from Indian Himalayan Region (IHR). *Biodiversity and conservation,* **18,** 1273-1286.

Maldonado, J.H. & González-Vega, C. (2008) Impact of Microfinance on Schooling: Evidence from Poor Rural Households in Bolivia. *World Development,* **36,** 2440-2455.

Malhi, Y., Baldocchi, D.D. & Jarvis, P.G. (1999) The carbon balance of tropical, temperate and boreal forests. *Plant, Cell & Environment,* **22,** 715-740.

Manning, W.J. & Feder, W.A. (1980) *Biomonitoring air pollutants with plants.* Applied Science Publishers.

Maraseni, T.N., Shivakoti, G.P., Cockfield, G. & Apan, A. (2006) Nepalese non-timber forest products: an analysis of the equitability of profit distribution across a supply chain to India. *Small-Scale Forestry,* **5,** 191-206.

Maryudi, A. & Krott, M. (2012) Local Struggle for Accessing State Forest Property in a Montane Forest Village in Java, Indonesia. *Journal of Sustainable Development,* **5**.

Massey, D.S. (1990) Social Structure, Household Strategies, and the Cumulative Causation of Migration. *Population Index,* **56,** 3-26.

Mastrangelo, M.E., Gavin, M.C., Laterra, P., Linklater, W.L. & Milfont, T.L. (2014) Psycho-Social Factors Influencing Forest Conservation Intentions on the Agricultural Frontier. *Conservation Letters,* **7,** 103-110.

Mathie, A. & Cunningham, G. (2003) From clients to citizens: Asset-based Community Development as a strategy for community-driven development. *Development in Practice,* **13,** 474-486.

Matson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. (1997) Agricultural Intensification and Ecosystem Properties. *Science,* **277,** 504-509.

Mattila, P., Könkö, K., Eurola, M., Pihlava, J.-M., Astola, J., Vahteristo, L., Hietaniemi, V., Kumpulainen, J., Valtonen, M. & Piironen, V. (2001) Contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. *Journal of agricultural and food chemistry,* **49,** 2343-2348.

Mavsar, R., Varela, E. & Duclercq, M. (2014) Methods and tools for socio-economic assessment of goods and services provided by Mediterranean forest ecosystems. PLAN BLEU, Valbonne, France.

Maynard, S., James, D. & Davidson, A. (2015) Determining the value of multiple ecosystem services in terms of community wellbeing: Who should be the valuing agent? *Ecological Economics,* **115,** 22-28.

McDermott, J.J., Staal, S.J., Freeman, H.A., Herrero, M. & Van de Steeg, J.A. (2010) Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Science,* **130,** 95-109.

McDonald, E., Bailie, R., Grace, J. & Brewster, D. (2010) An ecological approach to health promotion in remote Australian Aboriginal communities. *Health promotion international,* **25,** 42-53.

McElwee, P. (2004) You Say Illegal, I Say Legal. *Journal of Sustainable Forestry,* **19,** 97-135.

McElwee, P.D. (2008) Forest environmental income in Vietnam: household socioeconomic factors influencing forest use. *Environmental Conservation,* **35,** 147-159.

McPeak, J.G. & Barrett, C.B. (2001) Differential risk exposure and stochastic poverty traps among East African pastoralists. *American Journal of Agricultural Economics,* **83,** 674-679.

McShane, T.O., Hirsch, P.D., Trung, T.C., Songorwa, A.N., Kinzig, A., Monteferri, B., Mutekanga, D., Thang, H.V., Dammert, J.L., Pulgar-Vidal, M., Welch-Devine, M., Peter Brosius, J., Coppolillo, P. & O'Connor, S. (2011) Hard choices: Making trade-offs between biodiversity conservation and human well-being. *Biological Conservation,* **144,** 966-972.

MEA (2003) *Ecosystems and human well-being: A Framework for Assessment.* Island Press, Washington, DC.

MEA (2005) *Ecosystems and human well-being: Sythesis.* Island Press, Washington, DC.

Melnick, D. (2005) *Environment and human well-being: a practical strategy.* Earthscan.

Mendola, M. (2008) Migration and technological change in rural households: Complements or substitutes? *Journal of Development Economics,* **85,** 150-175.

Menzel, S. & Teng, J. (2010) Ecosystem services as a stakeholder-driven concept for conservation science. *Conservation Biology:,* **24,** 907.

Meric, H.J. & Hunt, J. (1998) Ecotourists' Motivational and Demographic Characteristics: A Case of North Carolina Travelers. *Journal of Travel Research,* **36,** 57-61.

Miah, G., Bari, N. & Rahman, A. (2010) Resource degradation and livelihood in the coastal region of Bangladesh. *Frontiers of Earth Science in China*, **4,** 427-437.

Milne, S. (2015) Cambodia's Unofficial Regime of Extraction: Illicit Logging in the Shadow of Transnational Governance and Investment. *Critical Asian Studies,* **47,** 200-228.

Ministry of Planning (2014) Cambodia Socio Economic Survey- 2013. *Cambodia Sociao-Economic Survey*, pp. 86. National Institute of Statistics, Phnom Penh

Mitra, M. (2000) The Sundarbans: a riparian commons in search of management. *Eighth conference of the international association for the study of common property, Bloomingdale, IN, USA.*

Mogas, J., Riera, P. & Bennett, J. (2006) A comparison of contingent valuation and choice modelling with second-order interactions. *Journal of Forest Economics,* **12,** 5-30.

Mohsanin, S., Barlow, A.C.D., Greenwood, C.J., Islam, M.A., Kabir, M.M., Rahman, M.M. & Howlader, A. (2013) Assessing the threat of human consumption of tiger prey in the Bangladesh Sundarbans. *Animal Conservation,* **16,** 69-76.

Monbiot, G. (2012) Putting a price on the rivers and rain diminishes us all. *The Guardian.*

More, T.A., Stevens, T. & Allen, P.G. (1988) Valuation of urban parks. *Landscape and Urban Planning,* **15,** 139-152.

Morley, O. (2015) *Key resource use of Northern yellow-cheeked crested Gibbon (Nomascus annamensis).* Honours Honours thesis, The Australian National University ACT, Australia

Muhammed, N., Koike, M. & Haque, F. (2008) Forest policy and sustainable forest management in Bangladesh: an analysis from national and international perspectives. *New Forests,* **36,** 201-216.

Müller, O. & Krawinkel, M. (2005) Malnutrition and health in developing countries. *Canadian Medical Association Journal,* **173,** 279-286.

Mullington, J.M., Haack, M., Toth, M., Serrador, J. & Meier-Ewert, H. (2009) Cardiovascular, Inflammatory and Metabolic Consequences of Sleep Deprivation. *Progress in Cardiovascular Diseases,* **51,** 294-302.

Murdock, J. (2006) Handling unobserved site characteristics in random utility models of recreation demand. *Journal of Environmental Economics and Management,* **51,** 1-25.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature,* **403,** 853-858.

Naidu, S.C. (2011) Access to benefits from forest commons in the Western Himalayas. *Ecological Economics,* **71,** 202-210.

Narayan, D., Chambers, R., Shah, M.K. & Petesch, P. (2000) Voices of the Poor: Crying out for Change. World Bank, Washington DC.

Nath, T.K. & Inoue, M. (2009) Forest-based settlement project and its impacts on community livelihood in the Chittagong Hill Tracts, Bangladesh. *International Forestry Review,* **11,** 394-407.

Naylor, L.A., Viles, H.A. & Carter, N.E.A. (2002) Biogeomorphology revisited: looking towards the future. *Geomorphology,* **47,** 3-14.

Ndangalasi, H.J., Bitariho, R. & Dovie, D.B.K. (2007) Harvesting of non-timber forest products and implications for conservation in two montane forests of East Africa. *Biological Conservation,* **134,** 242-250.

Ndoye, O. & Tieguhong, J.C. (2004) Forest Resources and Rural Livelihoods: The Conflict Between Timber and Non-timber Forest Products in the Congo Basin. *Scandinavian Journal of Forest Research,* **19,** 36-44.

Negassi, A., Bein, E., Ghebru, K. & Tengnas, B. (2002) Soil and water conservation manual for Eritrea. *RELMA, Technical Handbook Series,* **29**.

Nelson, B. (2013) *Sleeping Tree Selection by Norther Yellow-cheeked Crested Gibbons (Nomascus annamensis) in Cambodia*. MSc, The Australian National University ACT, Australia.

Nguyen, T.Q. (2006) Forest devolution in Vietnam: Differentiation in benefits from forest among local households. *Forest Policy and Economics,* **8,** 409-420.

Nijman, V. (2010) An overview of international wildlife trade from Southeast Asia. *Biodiversity and Conservation,* **19,** 1101-1114.

Ninan, K.N. & Inoue, M. (2013) Valuing forest ecosystem services: Case study of a forest reserve in Japan. *Ecosystem Services,* **5,** 78-87.

Nkhata, A., Breen, C. & Freimund, W. (2008) Resilient social relationships and collaboration in the management of social–ecological systems. *Ecology and Society,* **13**.

Nkonya, E., Schroeder, T. & Norman, D. (1997) Factors affecting adoption of improved maize seed and fertiliser in nothern Tanzania. *Journal of Agricultural Economics,* **48,** 1-12.

Noss, A.J. (2002) Cable snares and bushmeat markets in a central African forest. *Environmental Conservation,* **25,** 228-233.

Nowak, D.J., Crane, D.E. & Stevens, J.C. (2006) Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening,* **4,** 115-123.

Nowak, D.J., Hirabayashi, S., Bodine, A. & Greenfield, E. (2014) Tree and forest effects on air quality and human health in the United States. *Environmental Pollution,* **193,** 119-129.

Obidzinski, K., Dermawan, A., Andrianto, A., Komarudin, H. & Hernawan, D. (2014) The timber legality verification system and the voluntary partnership agreement (VPA) in Indonesia: Challenges for the small-scale forestry sector. *Forest Policy and Economics,* **48,** 24-32.

OECD (2013) Measuring Well-Being and Progress. OECD Statistics Directorate, Paris.

Okello, M.M. & Yerian, S. (2009) Tourist satisfaction in relation to attractions and implications for conservation in the protected areas of the Northern Circuit, Tanzania. *Journal of Sustainable Tourism,* **17,** 605-625.

Olson, D.M. & Dinerstein, E. (1998) The Global 200: a representation approach to conserving the Earth's most biologically valuable ecoregions. *Conservation Biology,* **12,** 502-515.

Osborn, D.P.J. (2001) The poor physical health of people with mental illness. *Western Journal of Medicine,* **175,** 329-332.

Osman-Elasha, B., Goutbi, N., Spanger-Siegfried, E., Dougherty, B., Hanafi, A., Zakieldeen, S., Sanjak, A., Atti, H.A. & Elhassan, H.M. (2006) Adaptation strategies to increase human resilience against climate variability and change: Lessons from the arid regions of Sudan. *Assessments of Impacts and Adaptations to Climate Change (AIACC) Working Paper,* **42**.

Osti, R., Tanaka, S. & Tokioka, T. (2009) The importance of mangrove forest in tsunami disaster mitigation. *Disasters,* **33,** 203-213.

Othman, J., Bennett, J. & Blamey, R. (2004) Environmental values and resource management options: a choice modelling experience in Malaysia. *Environment and Development Economics,* **9,** 803-824.

Pagdee, A., Kim, Y.-s. & Daugherty, P.J. (2006) What Makes Community Forest Management Successful: A Meta-Study From Community Forests Throughout the World. *Society & Natural Resources,* **19,** 33-52.

Palacio, V. (1997) Identifying Ecotourists in Belize Through Benefit Segmentation: A Preliminary Analysis. *Journal of Sustainable Tourism,* **5,** 234-243.

Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F. & Wilkinson, R. (2006) Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture,* **46,** 1407-1424.

Parasuraman, S. & Simmers, C.A. (2001) Type of employment, work–family conflict and well-being: a comparative study. *Journal of Organizational Behavior,* **22,** 551-568.

Pascual, U., Muradian, R., Brander, L., Gómez-Baggethun, E., Martín-López, B., Verma, M., Armsworth, P., Christie, M., Cornelissen, H. & Eppink, F. (2010) The economics of valuing ecosystem services and biodiversity.

Paudel, G.S. & Thapa, G.B. (2004) Impact of social, institutional and ecological factors on land management practices in mountain watersheds of Nepal. *Applied Geography,* **24,** 35-55.

Paul, B.G. & Vogl, C.R. (2011) Impacts of shrimp farming in Bangladesh: Challenges and alternatives. *Ocean & Coastal Management,* **54,** 201-211.

Pearce, D.W. & Warford, J.J. (1993) World without end: Economics, environment, and sustainable development. International Bank for Reconstruction and Development, Washington, DC (United States).

Pelling, M. (1998) Participation, social capital and vulnerability to urban flooding in Guyana. *Journal of International Development,* **10,** 469-486.

Peluso, N.L. (1996) Fruit trees and family trees in an anthropogenic forest: Ethics of access, property zones, and environmental change in Indonesia. *Comparative studies in Society and History,* **38,** 510-548.

Persson, L., Phirun, N., Ngin, C., Pilgrim, J., Sam, C. & Noel, S. (2010) Ecosystem Services Supporting Livelihoods in Cambodia. Stockholm Environment Institute.

Pielke, R.A., Marland, G., Betts, R.A., Chase, T.N., Eastman, J.L., Niles, J.O., Niyogi, D.d.S. & Running, S.W. (2002) The influence of land-use change and landscape dynamics on the climate system: relevance to climate-change policy beyond the radiative effect of greenhouse gases. *Philosophical Transactions of the Royal*

Society of London. Series A: Mathematical, Physical and Engineering Sciences, **360,** 1705-1719.

Pimentel, D., Harvey, C., Resosudarmo, P. & Sinclair, K. (1995) Environmental and economic costs of soil erosion and conservation benefits. *Science,* **267,** 1117.

Piper, S. & Martin, W.E. (2001) Evaluating the accuracy of the benefit transfer method: A rural water supply application in the USA. *Journal of Environmental Management,* **63,** 223-235.

POH-KAO (2012) Project Ending Report July 2009-June 2012. POH KAO des Tibers et des Hommes.

Ponte, S. (2012) The Marine Stewardship Council (MSC) and the Making of a Market for 'Sustainable Fish'. *Journal of Agrarian Change,* **12,** 300-315.

Porter, G., Hampshire, K., Abane, A., Tanle, A., Esia-Donkoh, K., Obilie Amoako-Sakyi, R., Agblorti, S. & Asiedu Owusu, S. (2011) Mobility, education and livelihood trajectories for young people in rural Ghana: a gender perspective. *Children's Geographies,* **9,** 395-410.

Poteete, A.R. & Ostrom, E. (2004) Heterogeneity, group size and collective action: the role of institutions in forest management. *Development and change,* **35,** 435-461.

Power, A.G. (2010) Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical Transactions of the Royal Society B: Biological Sciences,* **365,** 2959-2971.

Powicki, C.R. (1998) The value of ecological resources. *EPRI Journal,* **23,** 8-17.

PPWS (2015) Annual Report 2015. Phnom Penh Water Supply Authority, Phnom Penh.

Pretty, J. & Smith, D. (2004) Social Capital in Biodiversity Conservation and Management

Capital Social en la Conservación y Gestión de la Biodiversidad. *Conservation Biology,* **18,** 631-638.

Putnam, R.D., Leonardi, R. & Nanetti, R.Y. (1993) *Making democracy work: Civic traditions in modern Italy.* Princeton university press.

Rakodi, C. (1999) A Capital Assets Framework for Analysing Household Livelihood Strategies: Implications for Policy. *Development Policy Review,* **17,** 315-342.

Ramachandra, A., Uraguchi A & Rawson BM (2012) Veun Sai-Siem Pang Conservation Area : REDD + Pre-feasibility Study. Conservation International, Phnom Penh, Cambodia.

Rangan, H. (1997) Property vs. control: The state and forest management in the Indian Himalaya. *Development and Change,* **28,** 71-94.

Rawson, B.M. & Bach, L.T. (2011) Preliminary observations of geophagy amongst Cambodia's Colobinae. *Vietnamese Journal of Primatology* **5,** 41-46.

Rawson, B.M., Reiter, C.N., Masphal, K., M., M. & Omaliss, K. (2012) Veun Sai-Siem Pang Conservation Area: Biodiversity Values and Conservation Plan. Conservation Internationa and Forestry Administraion Phnom Penh.

Reimer, J.K. & Walter, P. (2013) How do you know it when you see it? Community-based ecotourism in the Cardamom Mountains of southwestern Cambodia. *Tourism Management,* **34,** 122-132.

Reisinger, Y. & Turner, L.W. (2003) *Cross-cultural behaviour in tourism: Concepts and analysis.* Elsevier.

Rey, F. (2003) Influence of vegetation distribution on sediment yield in forested marly gullies. *CATENA,* **50,** 549-562.

Ribot, J.C. (1995) From exclusion to participation: Turning Senegal's forestry policy around? *World Development,* **23,** 1587-1599.

Ribot, J.C. (1998) Theorizing Access: Forest Profits along Senegal's Charcoal Commodity Chain. *Development and Change,* **29,** 307-341.

Ribot, J.C. & Peluso, N.L. (2003) A Theory of Access*. *Rural Sociology,* **68,** 153-181.

Robbins, P. (2000) The rotten institution: corruption in natural resource management. *Political Geography,* **19,** 423-443.

Robinson, J.G. (1993) The Limits to Caring: Sustainable Living and the Loss of Biodiversity

Los limites de cuidari: vida sostenible y la pérdida de biodiversidad. *Conservation Biology,* **7,** 20-28.

Rogerson, P. (2001) *Statistical methods for geography.* Sage.

Rosenberger, R.S. & Loomis, J.B. (2000) Using meta-analysis for benefit transfer: In-sample convergent validity tests of an outdoor recreation database. *Water Resources Research,* **36,** 1097-1107.

Roy, A.K.D., Alam, K. & Gow, J. (2013) Community perceptions of state forest ownership and management: A case study of the Sundarbans Mangrove Forest in Bangladesh. *Journal of Environmental Management,* **117,** 141-149.

Roy, R., Finck, A., Blair, G. & Tandon, H. (2006) Plant nutrition for food security. *A guide for integrated nutrient management. FAO Fertilizer and Plant Nutrition Bulletin,* **16,** 368.

Rozelle, S., Guo, L., Shen, M., Hughart, A. & Giles, J. (1999) Leaving China's farms: survey results of new paths and remaining hurdles to rural migration. *The China Quarterly,* **158,** 367-393.

Rudel, T.K., Bates, D. & Machinguiashi, R. (2002) A Tropical Forest Transition? Agricultural Change, Out-migration, and Secondary Forests in the Ecuadorian Amazon. *Annals of the Association of American Geographers,* **92,** 87-102.

Safa, M. (2004) The effect of participatory forest management on the livelihood and poverty of settlers in a rehabilitation program of degraded forest in Bangladesh. *Small-scale Forest Economics, Management and Policy,* **3,** 223-238.

Salafsky, N., Cauley, H., Balachander, G., Cordes, B., Parks, J., Margoluis, C., Bhatt, S., Encarnacion, C., Russell, D. & Margoluis, R. (2001) A Systematic Test of an Enterprise Strategy for Community-Based Biodiversity Conservation

Prueba Sistemática de Estrategias Empresariales para la Conservación de la Biodiversidad Basada en la Comunidad. *Conservation Biology,* **15,** 1585-1595.

Salafsky, N. & Wollenberg, E. (2000) Linking Livelihoods and Conservation: A Conceptual Framework and Scale for Assessing the Integration of Human Needs and Biodiversity. *World Development,* **28,** 1421-1438.

Salam, M.A., Lindsay, G.R. & Beveridge, M.C. (2000) Eco-tourism to protect the reserve mangrove forest the Sundarbans and its flora and fauna. *Anatolia,* **11,** 56-66.

Salam, M.A., Noguchi, T. & Koike, M. (2005) Factors influencing the sustained participation of farmers in participatory forestry: a case study in central Sal forests in Bangladesh. *Journal of Environmental Management,* **74,** 43-51.

Santiphop, T., Shrestha, R.P. & Hazarika, M.K. (2011) An analysis of factors affecting agricultural land use patterns and livelihood strategies of farm households in Kanchanaburi Province, Thailand. *Journal of Land Use Science,* **7,** 331-348.

Scheffers, B.R., Corlett, R.T., Diesmos, A. & Laurance, W.F. (2012) Local Demand Drives a Bushmeat Industry in a Philippine Forest Preserve. *Tropical Conservation Science,* **5,** 133-141.

Schlaepfer, M.A., Hoover, C. & Dodd Jr, C.K. (2005) Challenges in evaluating the impact of the trade in amphibians and reptiles on wild populations. *BioScience,* **55,** 256-264.

Scholte, P. & De Groot, W.T. (2010) From Debate to Insight: Three Models of Immigration to Protected Areas. *Conservation Biology,* **24,** 630-632.

Schwartzman, S.H. & AKO Nepstad, D. (1992) The dynamics of extraction in Amazonia: a historical perspectiveNon-timber products from tropical forests; evaluation of a conservation and development strategy.

Scoones, I. (1998) Sustainable Rural Livelihoods: A Framework for Analysis. Brighton, IDS.

Seeman, T.E. (1996) Social ties and health: The benefits of social integration. *Annals of Epidemiology,* **6,** 442-451.

Seidenstlcker, J. & Hai, M.A. (1983) The sundarbans Wildlife Management Plan: Conservation in the Banglaesh Coastal Zone. IUCN, Gland, Switzerland

Sen, A. (1983) *Poverty and Famines: An Essay on Entitlement and Deprivation.* Oxford University Press, Oxford.

Sen, B. (2003) Drivers of Escape and Descent: Changing Household Fortunes in Rural Bangladesh. *World Development,* **31,** 513-534.

Seneca Creek Associates, L. (2004) *" Illegal" Logging and Global Wood Markets: The Competitive Impacts on the US Wood Products Industry.* American Forest & Paper Association.

Sengupta, R. (2002) Human Well-Being and Sustainable Development. *Economic and Political Weekly,* **37,** 4289-4294.

Shackleton, S., Campbell, B., Wollenberg, E. & Edmunds, D. (2002) Devolution and community-based natural resource management: Creating space for local people to participate and benefit. *Natural Resource Perspectives,* **76,** 1-6.

Shanley, P., Luz, L. & Swingland, I.R. (2002) The faint promise of a distant market: a survey of Belém's trade in non-timber forest products. *Biodiversity & Conservation,* **11,** 615-636.

Sharma, C.K. (1996) Overview of Nepal's energy sources and environment. *Atmospheric Environment,* **30,** 2717-2720.

Sharpley, R. (2007) Flagship Attractions and Sustainable Rural Tourism Development: The Case of the Alnwick Garden, England. *Journal of Sustainable Tourism,* **15,** 125-143.

Sheppard, S.R.J. & Meitner, M. (2005) Using multi-criteria analysis and visualisation for sustainable forest management planning with stakeholder groups. *Forest Ecology and Management,* **207,** 171-187.

Shoemaker, S. & Lewis, R.C. (1999) Customer loyalty: the future of hospitality marketing. *International Journal of Hospitality Management,* **18,** 345-370.

Slinker, B.K. & Glantz, S.A. (1985) Multiple regression for physiological data analysis: the problem of multicollinearity. *American Journal of Physiology - Regulatory, Integrative and Comparative Physiology,* **249,** R1-R12.

Smith, L.M., Case, J.L., Smith, H.M., Harwell, L.C. & Summers, J.K. (2013) Relating ecoystem services to domains of human well-being: Foundation for a U.S. index. *Ecological Indicators,* **28,** 79-90.

Smith, M.R., Singh, G.M., Mozaffarian, D. & Myers, S.S. (2015) Effects of decreases of animal pollinators on human nutrition and global health: a modelling analysis. *The Lancet,* **386,** 1964-1972.

Sodhi, N.S., Posa, M.R.C., Lee, T.M., Bickford, D., Koh, L.P. & Brook, B.W. (2010) The state and conservation of Southeast Asian biodiversity. *Biodiversity and Conservation,* **19,** 317-328.

Solow, R.M. (1956) A contribution to the theory of economic growth. *The quarterly journal of economics,* **70,** 65-94.

Solow, R.M. (1973) Is the End of the World at Hand? *Challenge,* **16,** 39-50.

Solow, R.M. (1974) The economics of resources or the resources of economics. *Classic papers in natural resource economics,* pp. 257-276. Springer.

Someth, P., Pen, C., Sean, P., Hang, L. & Chanthy, S. (2010) Catchment profile of the Sekong, Sesan and Srepok (3S) Rivers (in Cambodia). Institute of Technology of Cambodia, Phnom Penh, Cambodia.

Song, M.-K., Lin, F.-C., Ward, S.E. & Fine, J.P. (2013) Composite Variables: When and How. *Nursing research,* **62,** 45-49.

Songorwa, A.N. (1999) Community-Based Wildlife Management (CWM) in Tanzania: Are the Communities Interested? *World Development,* **27,** 2061-2079.

Spenceley, A., Habyalimana, S., Tusabe, R. & Mariza, D. (2010) Benefits to the poor from gorilla tourism in Rwanda. *Development Southern Africa,* **27,** 647-662.

Stachowicz, J.J., Bruno, J.F. & Duffy, J.E. (2007) Understanding the Effects of Marine Biodiversity on Communities and Ecosystems. *Annual Review of Ecology, Evolution, and Systematics,* **38,** 739-766.

Stark, O. & Wang, Y. (2002) Inducing human capital formation: migration as a substitute for subsidies. *Journal of Public Economics,* **86,** 29-46.

Stephen R. Kellert, J.N.M.S. (2000) Community Natural Resource Management: Promise, Rhetoric, and Reality. *Society & Natural Resources,* **13,** 705-715.

Steptoe, A., Deaton, A. & Stone, A.A. (2015) Subjective wellbeing, health, and ageing. *Ageing 4*, pp. 640-648. The Lancet.

Stewart, K. (2005) Dimensions of well-being in EU regions: Do GDP and unemployment tell us all we need to know? *Social Indicators Research,* **73,** 221-246.

Stewart, K.M. (2003) The African Cherry (Prunus africana): From hoe-handles to the international herb market. *Economic Botany,* **57,** 559-569.

Stone, M. & Wall, G. (2004) Ecotourism and Community Development: Case Studies from Hainan, China. *Environmental Management,* **33,** 12-24.

Stronza, A. (2007) The Economic Promise of Ecotourism for Conservation. *Journal of Ecotourism,* **6,** 210-230.

Stronza, A. (2009) The Economic Promise of Ecotourism for Conservation. *Journal of Ecotourism,* **6,** 210-230.

Stronza, A. & Gordillo, J. (2008) Community views of ecotourism. *Annals of Tourism Research,* **35,** 448-468.

Sullivan, J.L., Baker, R.E., Boyer, B.A., Hammerle, R.H., Kenney, T.E., Muniz, L. & Wallington, T.J. (2004) CO2 Emission Benefit of Diesel (versus Gasoline) Powered Vehicles. *Environmental Science & Technology,* **38,** 3217-3223.

Sunderlin, W.D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L. & Wunder, S. (2005) Livelihoods, forests, and conservation in developing countries: An Overview. *World Development,* **33,** 1383-1402.

Tacconi, L. (2007) Decentralization, forests and livelihoods: Theory and narrative. *Global Environmental Change,* **17,** 338-348.

Takenaka, A. & Pren, K.A. (2010) Determinants of Emigration: Comparing Migrants' Selectivity from Peru and Mexico. *The ANNALS of the American Academy of Political and Social Science,* **630,** 178-193.

Tamason, C.C., Tulsiani, S.M., Siddique, A.K., Hoque, B.A. & Mackie Jensen, P.K. (2016) What is cholera? A preliminary study on caretakers' knowledge in Bangladesh. *Journal of Health, Population and Nutrition,* **35,** 3.

Tawney, R. (1978) Property and creative work. *Property: mainstream and critical positions,* 133-51.

Thinh, V., Alan R, Thanh, V.N., Nadler, T. & Roos, C. (2010) A new species of crested gibbon, from the central Annamite mountain range. *Vietnamese Journal of Primatology,* **4,** 1-12.

Thoeun, H.C. (2015) Observed and projected changes in temperature and rainfall in Cambodia. *Weather and Climate Extremes,* **7,** 61-71.

Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G. & Rockström, J. (2006) Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters,* **30,** 39-48.

Thomas, C.D., Cameron, A., Green, R.E., Bakkenes, M., Beaumont, L.J., Collingham, Y.C., Erasmus, B.F.N., de Siqueira, M.F., Grainger, A., Hannah, L., Hughes, L., Huntley, B., van Jaarsveld, A.S., Midgley, G.F., Miles, L., Ortega-Huerta, M.A., Townsend Peterson, A., Phillips, O.L. & Williams, S.E. (2004) Extinction risk from climate change. *Nature,* **427,** 145-148.

Thomas, D.S.G. & Twyman, C. (2005) Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change,* **15,** 115-124.

Thompson, B. & Amoroso, L. (2010) *Combating micronutrient deficiencies: food-based approaches.* CABI.

Thoms, C.A. (2008) Community control of resources and the challenge of improving local livelihoods: A critical examination of community forestry in Nepal. *Geoforum,* **39,** 1452-1465.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R. & Polasky, S. (2002) Agricultural sustainability and intensive production practices. *Nature,* **418,** 671-677.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W.H., Simberloff, D. & Swackhamer, D. (2001) Forecasting Agriculturally Driven Global Environmental Change. *Science,* **292,** 281-284.

Tilman, D., Lehman, C.L. & Thomson, K.T. (1997) Plant diversity and ecosystem productivity: Theoretical considerations. *Proceedings of the National Academy of Sciences,* **94,** 1857-1861.

Timsina, N.P. (2003) Promoting social justice and conserving montane forest environments: a case study of Nepal's community forestry programme. *Geographical Journal,* **169,** 236-242.

Toth, J.F., Brown, R.B. & Xu, X. (2002) Separate family and community realities? An urban-rural comparison of the association between family life satisfaction and community satisfaction. *Community, Work & Family,* **5,** 181-202.

Tscharntke, T., Clough, Y., Wanger, T.C., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J. & Whitbread, A. (2012) Global food security, biodiversity conservation and the future of agricultural intensification. *Biological Conservation,* **151,** 53-59.

Tscharntke, T., Klein, A.M., Kruess, A., Steffan-Dewenter, I. & Thies, C. (2005) Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters,* **8,** 857-874.

Turner, R.K., Paavola, J., Cooper, P., Farber, S., Jessamy, V. & Georgiou, S. (2003) Valuing nature: lessons learned and future research directions. *Ecological Economics,* **46,** 493-510.

Uberhuaga, P., Smith-Hall, C. & Helles, F. (2012) Forest income and dependency in lowland Bolivia. *Environment, Development and Sustainability,* **14,** 3-23.

Uddin, M.S., de Ruyter van Steveninck, E., Stuip, M. & Shah, M.A.R. (2013) Economic valuation of provisioning and cultural services of a protected mangrove ecosystem: A case study on Sundarbans Reserve Forest, Bangladesh. *Ecosystem Services,* **5,** 88-93.

Valiela, I., Bowen, J.L. & York, J.K. (2001) Mangrove Forests: One of the World's Threatened Major Tropical EnvironmentsAt least 35% of the area of mangrove forests has been lost in the past two decades, losses that exceed those for tropical rain forests and coral reefs, two other well-known threatened environments. *BioScience,* **51,** 807-815.

van Riper, C.J., Kyle, G.T., Sutton, S.G., Barnes, M. & Sherrouse, B.C. (2012) Mapping outdoor recreationists' perceived social values for ecosystem services at Hinchinbrook Island National Park, Australia. *Applied Geography,* **35,** 164-173.

Varughese, G. & Ostrom, E. (2001) The Contested Role of Heterogeneity in Collective Action: Some Evidence from Community Forestry in Nepal. *World Development,* **29,** 747-765.

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E. & Kobugabe Berg, G. (2007) Forest environmental incomes and the rural poor. *Forest Policy and Economics,* **9,** 869-879.

Vitousek, P.M. (1994) Beyond Global Warming: Ecology and Global Change. *Ecology,* **75,** 1861-1876.

Vu, D.H., Muttaqi, K.M. & Agalgaonkar, A.P. (2015) A variance inflation factor and backward elimination based robust regression model for forecasting monthly electricity demand using climatic variables. *Applied Energy,* **140,** 385-394.

Wahid, S.M., Babel, M.S. & Bhuiyan, A.R. (2007) Hydrologic monitoring and analysis in the Sundarbans mangrove ecosystem, Bangladesh. *Journal of Hydrology,* **332,** 381-395.

Wainwright, J., Parsons, A.J. & Abrahams, A.D. (2000) Plot-scale studies of vegetation, overland flow and erosion interactions: case studies from Arizona and New Mexico. *Hydrological Processes,* **14,** 2921-2943.

Wallace, K.J. (2007) Classification of ecosystem services: Problems and solutions. *Biological Conservation,* **139,** 235-246.

Walpole, M.J. & Leader-Williams, N. (2002) Tourism and flagship species in conservation. *Biodiversity & Conservation,* **11,** 543-547.

WBCSD (2006) Water, Facts and Trends. *World Business Council for Sustainable Development*.

Weaver, J.L., Paquet, P.C. & Ruggiero, L.F. (1996) Resilience and Conservation of Large Carnivores in the Rocky Mountains

Resistencia y Conservación de Carnívoros Mayores en las Montañas Rocallosas. *Conservation Biology,* **10,** 964-976.

Weber, M. (1978) *Economy and society: An outline of interpretive sociology*. Univ of California Press.

Wells, M.P. & McShane, T.O. (2004) Integrating Protected Area Management with Local Needs and Aspirations. *AMBIO: A Journal of the Human Environment,* **33,** 513-519.

West, P.C., Narisma, G.T., Barford, C.C., Kucharik, C.J. & Foley, J.A. (2011) An alternative approach for quantifying climate regulation by ecosystems. *Frontiers in Ecology and the Environment,* **9,** 126-133.

Whitehead, J.C., Haab, T.C. & Huang, J.-C. (2000) Measuring recreation benefits of quality improvements with revealed and stated behavior data. *Resource and Energy Economics,* **22,** 339-354.

Whitehead, J.C., Pattanayak, S.K., Van Houtven, G.L. & Gelso, B.R. (2008) Combining revealed and stated preference data to estimate the nonmarket value of ecological services: an assessment of the state of science. *Journal of Economic Surveys,* **22,** 872-908.

Wilkie, D. & Carpenter, J. (1999) Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. *Biodiversity & Conservation,* **8,** 927-955.

Williams, J. (2016) *Environmental, anthropogenic and energetic predictors of the likelihood of Northern buff-cheeked crested gibbons (Nomascus annamensis) calling in Veun-Sai Siem Pang Conservation Area*. Honours Honours thesis, The Australian National University ACT, Australia.

Williams, P.H., Burgess, N.D. & Rahbek, C. (2000) Flagship species, ecological complementarity and conserving the diversity of mammals and birds in sub-Saharan Africa. *Animal Conservation,* **3,** 249-260.

Woolcock, M. (2001) The place of social capital in understanding social and economic outcomes. *Canadian journal of policy research,* **2,** 11-17.

World Bank (1993) The demand for water in rual areas: determinats and policy implications *The World Bank Research Observer,* **8,** 47-70.

World Bank (2007) World development report 2008: Agriculture for Development. The World Bank, Washington DC

World Bank (2016) http://databank.worldbank.org/data/reports.aspx?source=Global-Economic-Monitor-(GEM).

World Bank, Ecofys & Vivid Economics (2016) State and Trends of Carbon Pricing 2016. Washington DC.

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B., Lotze, H.K., Micheli, F. & Palumbi, S.R. (2006) Impacts of biodiversity loss on ocean ecosystem services. *science,* **314,** 787-790.

Wunder, S. (2000) Ecotourism and economic incentives — an empirical approach. *Ecological Economics,* **32,** 465-479.

Wunder, S. (2001) Poverty Alleviation and Tropical Forests—What Scope for Synergies? *World Development,* **29,** 1817-1833.

Wyche, S. & Steinfield, C. (2016) Why Don't Farmers Use Cell Phones to Access Market Prices? Technology Affordances and Barriers to Market Information Services Adoption in Rural Kenya. *Information Technology for Development,* **22,** 320-333.

Xi, J. (2009) Valuation of Ecosystem Services in Xishuangbanna Biodiversity Conservation Corridors Initiative Pilot Site, China. Asian Development Bank.

Xiang, Z., Yu, Y., Yang, M., Yang, J., Niao, M. & Li, M. (2011) Does flagship species tourism benefit conservation? A case study of the golden snub-nosed monkey in Shennongjia National Nature Reserve. *Chinese Science Bulletin,* **56,** 2553-2558.

Xie, G., Li, W., Xiao, Y., Zhang, B., Lu, C., An, K., Wang, J., Xu, K. & Wang, J. (2010) Forest ecosystem services and their values in Beijing. *Chinese Geographical Science,* **20,** 51-58.

Yanagisawa, H., Koshimura, S., Goto, K., Miyagi, T., Imamura, F., Ruangrassamee, A. & Tanavud, C. (2009) The reduction effects of mangrove forest on a tsunami based on field surveys at Pakarang Cape, Thailand and numerical analysis. *Estuarine, Coastal and Shelf Science,* **81,** 27-37.

Young, J.C., Jordan, A., R. Searle, K., Butler, A., S. Chapman, D., Simmons, P. & Watt, A.D. (2013) Does stakeholder involvement really benefit biodiversity conservation? *Biological Conservation,* **158,** 359-370.

Zarandian, A., Baral, H., Yavari, A., Jafari, H., Stork, N., Ling, M. & Amirnejad, H. (2016) Anthropogenic Decline of Ecosystem Services Threatens the Integrity of the Unique Hyrcanian (Caspian) Forests in Northern Iran. *Forests,* **7,** 51.

Ziegler, J., Dearden, P. & Rollins, R. (2012) But are tourists satisfied? Importance-performance analysis of the whale shark tourism industry on Isla Holbox, Mexico. *Tourism Management,* **33,** 692-701.

Appendices

Appendix 1: Front page of the published paper.

Ecosystem Services 26 (2017) 27–36

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

The value of ecosystem services obtained from the protected forest of Cambodia: The case of Veun Sai-Siem Pang National Park

Abu S.M.G. Kibria [a,*], Alison Behie [a], Robert Costanza [b], Colin Groves [a], Tracy Farrell [c]

[a] College of Arts & Social Science, The Australian National University, ACT 2601, Australia
[b] College of Asia Pacific, The Australian National University, ACT 2601, Australia
[c] Conservation International, Greater Mekong Region, Phnom Penh Center, Sothearos Corner Sihanouk Blvd, Phnom Penh, Cambodia

ARTICLE INFO

Article history:
Received 16 June 2016
Received in revised form 10 May 2017
Accepted 22 May 2017
Available online 9 June 2017

Keywords:
Ecosystem services
Monetary values
Non-monetary values
Service composition

ABSTRACT

This research provides for the first time a valuation of Veun Sai-Siem Pang National Park (VSSPNP) in Cambodia, which is a forest largely unfamiliar to the international community yet extremely significant in terms of biodiversity value. This study aimed to measure the monetary and non-monetary values of ecosystem services (ESS) of the forest. We estimated the total annual contribution of VSSPNP was US $129.84 million. Its primary contribution was air purification (US$56.21 million yr^{-1}) followed by water storage (US$32.31 million yr^{-1}), soil-erosion reduction (US$22.21 million yr^{-1}), soil-fertility improvement (US$9.47million yr^{-1}), carbon sequestration (US$7.87 million yr^{-1}), provisioning services (US $1.76 million yr^{-1}) and recreation (US$0.02 million yr^{-1}). Traditionally the forest is used for timber and non-timber forest products, which in fact, composed only 1.36% of the total benefits. By analysing the published articles and reports on VSSPNP we determined the area had generated valuable academic and non-academic knowledge on natural resources. This forest had also created a diverse network among scientists and different organizations worldwide. We also identified the forest to be of cultural importance for indigenous people as they believe that their ancestors live inside the forest and protect them from vulnerabilities. Despite being part of one of the most important eco-regions in the world VSSPNP is undervalued and facing multiple threats such as illegal logging, poaching, population pressure and corruption. The current estimation of ESS would thus assist in the sustainable management of VSSPNP.

1. Introduction

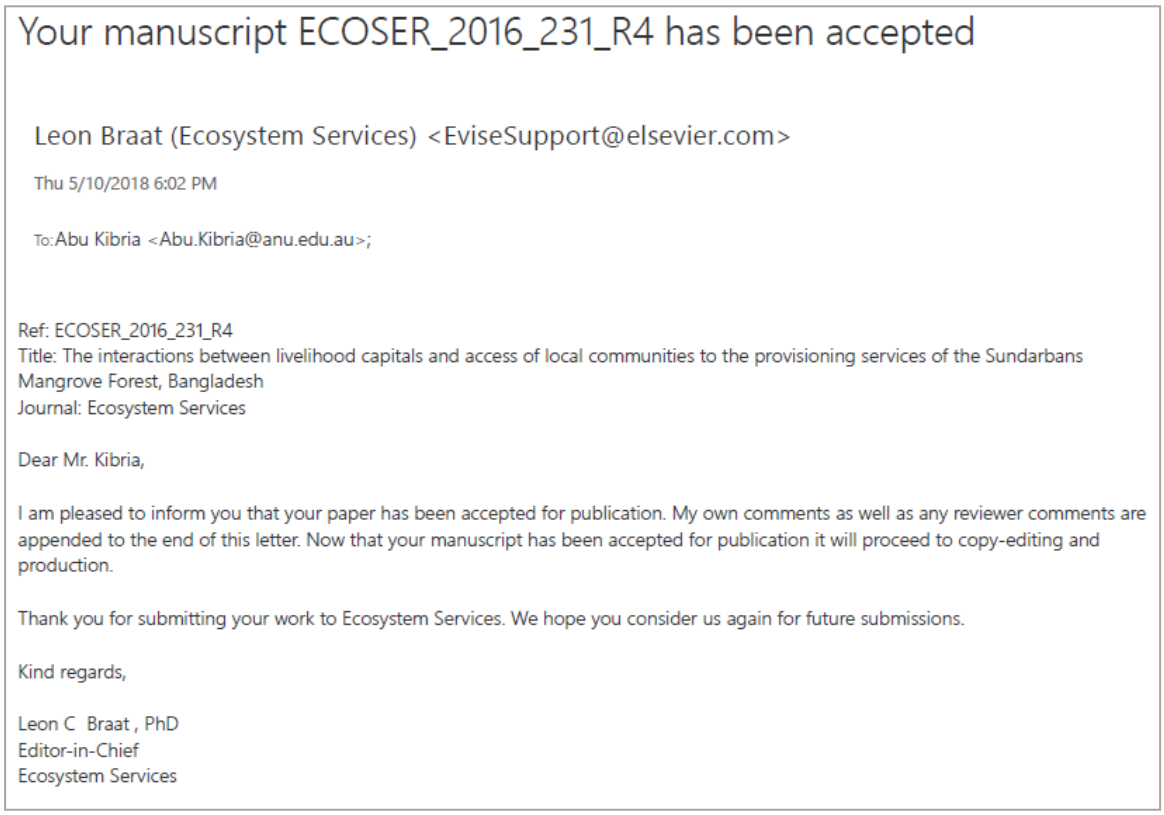
Forest ecosystems are capital assets that yield many vital services for humans (Costanza et al., 2011). Their importance, however, is often determined by comparing their value with that which could be obtained from converting forests for other land uses (i.e. agriculture) (Costanza et al., 1997). The ecosystem services (ESS) of forests identified by previous researchers are food, water, fuel, timber, fibre, climate regulation, flood regulation, disease regulation, water purification, and spiritual and recreational considerations (MEA, 2003; Fisher et al., 2014). These are broadly categorised in four groups- provisioning, regulating, cultural and supporting services.

Despite large potential ecosystem values, the increasing conversion of native ecosystems into agricultural land to meet ever increasing food demands worldwide is a major cause of habitat destruction and losses of valuable ecosystems (Tilman et al., 2001; Sunderlin et al., 2005). Land for agricultural expansion comes from forest, grassland and other natural ecosystems. If current global trends continue, net loss of natural ecosystems to agriculture would amount to 10^9 ha by 2050 – larger than the total area of the USA (Tilman et al., 2001). Tropical forests, by nearly all means, account for the richest biodiversity found anywhere in the world, yet, ironically, these forests are also among the most threatened (Valiela et al., 2001). Tropical forests are more than just a combination of flora and fauna; they are home to many indigenous people, and are vital source of numerous services such as flood amelioration, soil erosion control, fresh water supply, air purification, recreation, education and so on (Laurance, 1999; Costanza et al., 2014). The most prominent impact of tropical forest destruction is the loss of these precious ESS (Costanza et al., 1997; Daily et al., 2009; de Groot et al., 2012). This issue, however, has been largely ignored in forest and environmental policies, and conventional economic justifications have often underestimated the true contributions of forests. This has often led to the conversion

* Corresponding author at: AD Hope, 14 Ellery Crescent, The Australian National University, Canberra, ACT 2601, Australia.
E-mail addresses: abu.kibria@anu.edu.au, kibria.asmg@gmail.com (A.S.M.G. Kibria).

http://dx.doi.org/10.1016/j.ecoser.2017.05.008
2212-0416/

Appendix 2: Notification letter of the accepted manuscript.



Your manuscript ECOSER_2016_231_R4 has been accepted

Leon Braat (Ecosystem Services) <EviseSupport@elsevier.com>

Thu 5/10/2018 6:02 PM

To:Abu Kibria <Abu.Kibria@anu.edu.au>;

Ref: ECOSER_2016_231_R4
Title: The interactions between livelihood capitals and access of local communities to the provisioning services of the Sundarbans Mangrove Forest, Bangladesh
Journal: Ecosystem Services

Dear Mr. Kibria,

I am pleased to inform you that your paper has been accepted for publication. My own comments as well as any reviewer comments are appended to the end of this letter. Now that your manuscript has been accepted for publication it will proceed to copy-editing and production.

Thank you for submitting your work to Ecosystem Services. We hope you consider us again for future submissions.

Kind regards,

Leon C Braat , PhD
Editor-in-Chief
Ecosystem Services

Appendix 3: Questionnaire used to interview tourists.

Ecotourism Survey

(Note: Please do not give any identification of you. This is to understand the ecotourism value of the park. The data you are generating will be used in crucial decision making on entrance fee increase and improve facilities)

1. Country …….

2. Education ……

3. Age ……yr

4. Gender: M F

5. Employment/job: 1) Govt./ Pvt:……. 2) NGO……

3) University…… 4) Business……

6. Monthly gross income: ……..

1. Reasons of visit: a) learning b) just visit/holiday c) others:……..
2. Considering your income are you willing to pay as entrance fee $……

☐ Yes: Why……

☐ No: Why……

☐ No answer: (why)……

7. Considering your income are you willing to pay for watching Gibbon (endangered primate) $……..

☐ Yes: (why)……..

☐ No: (why)……

☐ No answer: (why)……..

8. Level of satisfaction: 1 (low) 2 3 4 5 (high)

9. Rank your plan for coming to enjoy (Put A/B/C/D/E/F):

1……..2……..4……5……..6…….

A Gibbons/ primates D Indigenous people

B Forests E Others (name):

C Birds F Not predetermined

10. Enjoyed most (Put A/B/C/D/E/F)

1……..2……..4…….5……..6……..

11. Expenditure:

Visit for: ……days

Expense: ……day

12. Came in group: yes: ……persons No.

Appendix 4: Questionnaire used to interview households

Human wellbeing

Basics materials for good life

1. Air to breath:

Q. Air is clean:

1) Strongly agree 2) Agree- some extent 3) Neutral
4) Disagree- some extent 5) Strongly disagree

2. Water for domestic use:

Water for drinking/cooking

Q. Distance to source of water:…….

Q. Availability:

>>>1) Sufficient amount 2) Moderately sufficient 3) Insufficient

>>>1) Available whole year 2) seasonal scarcity 3) scarcity manageable
4) scarcity hard to manage

Q. Water is clean: 1) strongly agree 2) agree- some extent 3) neutral 4) disagree- some extent 5) strongly disagree

Q. Taste of drinking water: 1) Good 2) Fair 3) Bad

Q. Risk to the health from water: 1) High 2) Minor 3) No 4) don't know

Q. Need to pay: 1) No 2) Yes: ……./lt

Q. Usage risk:

Water for other purposes

Q. Distance to source of water:……

Q. Availability:

>>>1) Sufficient amount 2) Moderately sufficient 3) Insufficient

>>>1) Available whole year 2) Seasonal scarcity 3) Scarcity manageable
4) Scarcity hard to manage

Q. Water is clean: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Usage risk:

3. Food

Q. Food from forest is enough to feed family:

1) Strongly agree 2) Agree- some extent 3) Neutral
4) Disagree- some extent 5) Strongly disagree

Q. Purchasing food: 1) Major amount 2) Moderate amount 3) Little supplement

Q. Chronic food shortage: 1) Moderate 2) Low 3) High

Q. Sudden shortage for how long:……..

Q. Seasonal/cyclic shortage:……times/yr for ……months/yr

Freedom of Choice

1. Institutions for freedom of choice

Q. Number of organization/person to defend right:……..

Q. Ability of that org./person: 1) Low 2) Moderate 3) High 4) Very high

Q. Impartial judiciary exists: Yes No

Q. Number of organization to restrain the right:

Q. Ability of that org./person: 1) Low 2) Moderate 3) High 4) Very high

2. Social freedom

Q. Free to do what is preferred

Q. Is there any threat against your preference?

Q. Members respect each other's preferences

Q. Punishment for damaging others' rights

Q. Others' preferences restrict me

Q. React against any threat

Q. Able to achieve in anyway (interference or hindrance)

3. Economic freedom

Q. Open markets for everyone:

Q. Can produce free whatever wants to:

Q. Can extract and sell the forest resources freely

4. Self-actualisation

Q. Can freely make choice and action for own benefit

Health

1. Physical health

Q. Physically feels weak: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Diseases per year: Male: Female: Children:

Q. Chronic diseases: 1) No. of- Male: Female:
Children:

Q. Toilet facility: 1) Sanitary 2) Unsanitary

Q. Aware of health: 1) Low 2) Moderate 3) High 4) Don't know

2. Mental Health

Q. Generally feels happy: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Self-esteem is high: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Regularly stressed: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Regularly depressed: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Security

Q. Personal security condition is good: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. There is certainty of employment: 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Certainty in supply of ESS 1) Strongly agree 2) Agree- some extent 3) Neutral 4) Disagree- some extent 5) Strongly disagree

Q. Do you have health insurance?

Q. Is there any co-operatives?

Q. Emergency money is managed from:

1. Neighbours and relatives (without interest) 2. Local lender (with interest) 3. Microfinance organizations 4. Bank

Livelihood capital

1. Education

	Age	Education
Male		
Female		
Children		
Son-1		
Son 2		
Son 3		
Son 4		
Daughter 1		
Daughter 2		
Daughter 3		
Daughter 4		

2. Income and expenditure

Expenses	Per month/week/yr		Income sources	Per month/week/yr	
	Before	After		Before	After

3. Resources from forests:

Items	Amount	Consumed	Sold
Food			
Housing materials			
Malva nut			
Resin			

Monkey /primate			
Other animals			
Water			

4. Financial capital

>>No. of Cow--- >>No. of Duck---

>>No. of Pig --- >>No. of Chicken ---

Q. No. of loan:…….

Q. Savings: Yes No.

Q. Wage/ salary:……/month

5. Physical capital

Q. House type:……

Q. Bicycle: Y N Q. Motorbike Y N

Q. Television/Radio Y N Q. Mobile Phone Y N

Q. Electricity Y N

Q. Equipment (Agr):…….

6. Natural capital

Q. Land: Own ……. Lease……..

Q. Forest area……..

Q. Water source: River Canal Creek Fountain

7. Social capital

1. Trust relations

Q. Most of the people in the community can be trusted

Q. How much local/ central govt. officials can be trusted:

1) Low 2) Moderate 3) High 4) No comment

2. Solidarity

q. Most of the people willing for non-financial assistance? 1. Agree strongly 2. Agree somewhat 3. Neither Nor 4. Disagree somewhat 5. Disagree strongly

q. Many people are willing to financial assistance? 1. Agree strongly 2. Agree somewhat 3. Neither Nor 4. Disagree somewhat 5. Disagree strongly

4. Network and groups

Q. With how many organizations/ groups you or family member are involved:……

Q. How many close

5. Social cohesion

Togetherness: 1. Vary distant 2. Somewhat distant 3. Neither distant nor close 4. Somewhat close 5. Very close

Peacefulness: 1. Very peaceful 2. Moderately peaceful 3. Neither nor 4. Moderately violent 5. Very violent

Reciprocity: Do you share extracted ESS with your neighbours and vice versa?